
Value Recovery from the Reverse Logistics Pipeline

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Prepared for the United States Army

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Preface

For the Army to transform into a more mobile force, the logistics footprint must shrink with a greater reliance on “reach.” This includes the quick and effective evacuation of unserviceable items. In that future, parts that are repaired quickly (but not in the battlespace) in support of a high-tempo operation may be an important source of supply to keep vehicles and equipment operationally ready. Longer-than-necessary process times for returning unserviceable components to available serviceable stocks cause excess inventory to be held. Thus it is important to improve retrograde and repair processes wherever practicable and possible, to eliminate unnecessary delays and non-value-adding steps for the soldier.

This analysis has been conducted in support of the Deputy Chief of Staff, G-4, Headquarters Department of the Army (HQDA), Reverse Logistics Process Action Team (RLPAT) and the Combined Arms Support Command (CASCOM) Distribution Management (DM) team. It should be of interest to logisticians throughout the Army, especially those dealing with spare parts and maintenance. It should also be of interest to supply chain managers in the commercial world.

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Summary

Value recovery in the form of the return and repair of reparable spare parts involves large amounts of time as well as inventory investment for the Army. This research defines metrics to evaluate the retrograde processes and establishes a baseline of performance based on fiscal year 2000.¹ In that year, approximately 603,000 individual unserviceable Class IX items² valued at almost \$2 billion were handled Army-wide by organizations below depot repair activities. Almost half of those items were repaired and returned to serviceable stocks; many were relatively inexpensive items. A significant dollar value also left Army inventories in the form of disposals or condemnations,³ although the bulk of the items were individually of low value.

Reparables are important because they are intended to be their own source of future serviceables. By definition, a “reparable” is an item that can be reconditioned or economically repaired for reuse when it becomes unserviceable.⁴ As part of a Level of Repair Analysis, the Army decides which parts should be repaired so that they can be used again, i.e., which parts are to be reparables rather than consumables that are automatically disposed of upon failure. Reparables are typically more expensive investment items that should be expeditiously moved to repair points for repair/refurbishment/remanufacture to return them to serviceable stocks so as to minimize the amount of inventory investment.

¹ Although the data are nearly three years old, no concerted attention has been directed at systemwide process improvements in the return and repair of reparables as a source of supply. The transition to Single Stock Fund (SSF) has shifted organizational boundaries, but the issues and magnitudes of the metrics are relatively unchanged today. Thus the recommendations remain current. See page 14 (footnote 6) and page 50 (footnote 17) for additional information and references to SSF changes.

² In the Department of Defense, there are 10 categories or classes into which supplies are grouped to facilitate supply management and planning. Class IX is defined as repair parts and components for equipment maintenance.

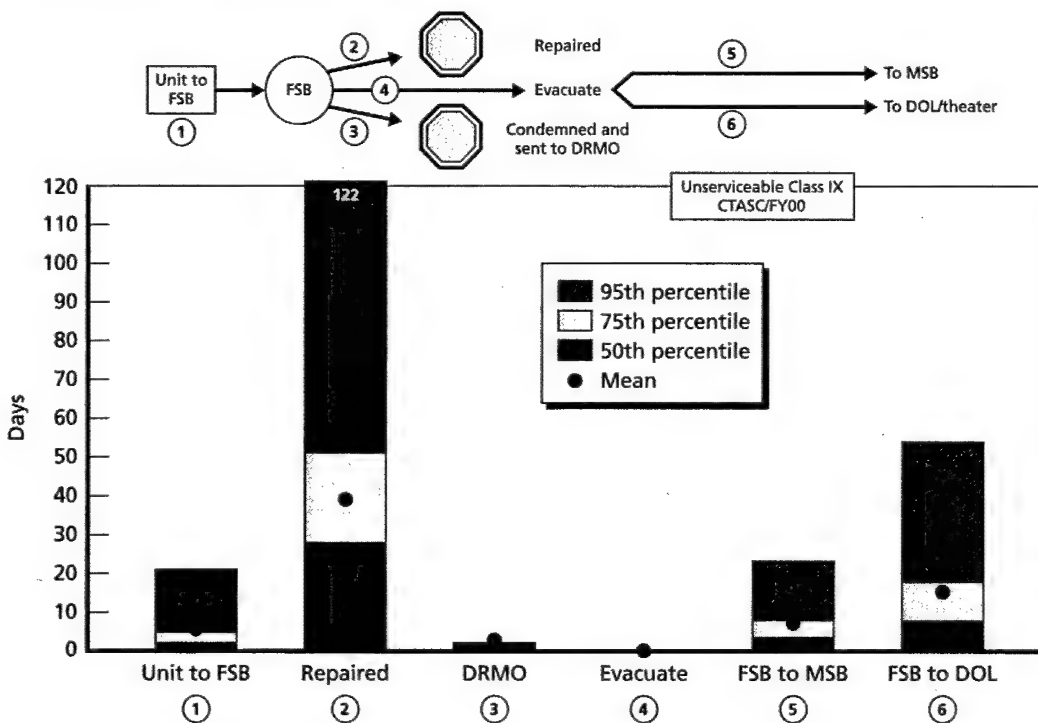
³ Items that are removed from inventory are usually sent to the local Defense Reutilization and Marketing Office (DRMO), which has the responsibility for disposing of such items.

⁴ Similarly, a “recoverable” item is one that normally is not consumed in use and is subject to return for repair or disposal.

Defining and Measuring the Reverse Logistics Process

Using fiscal year 2000 (FY00) as a baseline, we define the processes of recovering value from an unserviceable Class IX reparable—from turn-in by a soldier until it is repaired, condemned and disposed of, or evacuated to a higher echelon of repair. From the process definitions, metrics are calculated at three levels of activity: (a) forward support battalion (FSB), (b) main support battalion (MSB) and aviation support battalion (ASB), and (c) Director of Logistics (DOL) and theater-level repair activities. As an example, Figure S.1 depicts segment metrics for overall Army performance at the FSB level. Segment 1 (circled numbers on the figure depict segments) starts when an unserviceable item has been removed and replaced by a serviceable one and is then turned in by a mechanic to the supply system, starting the retrograde process. Once entered into the supply system, the unserviceable item then moves through a series of actions until it reaches final disposition: repair in the field, disposal, or unserviceable stock awaiting induction into a national source of repair. Depicted for each segment are the median, 75th percentile, 95th percentile, and

Figure S.1
FSB Processing of Unserviceable Retrograde



mean process times. In the top portion of the figure, the generalized process segments are shown and numbered to correspond to the metrics in the lower portion of the figure.

As the metrics in this report reflect, there are opportunities for improvement, as the total process times are long. In FY00, repair time for items that were repaired below depot level and returned to serviceable stocks averaged over 33 days. Items that were condemned and disposed of averaged 28 days to process, and items that were sent to depot level for repair averaged over 82 days to be moved to repair locations.

To help understand where improvements are possible, the metrics are portrayed at the three different organizational levels: FSB, MSB/ASB, and DOL/theater. For example, Figure S.1 shows Army-wide times for FSB-level processes. Then we examine performance in each of the process segments (e.g., turn-in process, repair process, various transit segments, etc.) for individual Army major commands (MACOMs) in Europe, Korea, the Pacific region, and the continental United States (CONUS).

Improving the Reverse Logistics Process

Some initial improvement ideas are also presented; these resulted from many observations made during process walks. With respect to the Army transformation and future operations, the quick and timely repair of unserviceable Class IX components may be critical to maintaining acceptable readiness levels as constrained by inventory investments. The focus and emphasis need to be on successful and timely value recovery—not just moving or piling up broken parts.

Improving the reverse pipeline involves an understanding of what constitutes “improvement.” The term “velocity management” has been used to focus primarily on reducing the order fulfillment time and variability when a customer orders a needed part; faster and/or more consistent deliveries are almost always going to be better. In reverse logistics, velocity is still relevant, but “faster” might not be the guiding principle. Thus, for reference, we define improving the flow in the reverse logistics pipeline to mean *timely movement to minimize the amount of inventory investment*. In other words, the objective is to make the most cost-effective use of existing inventories.

Timely return of unserviceable carcasses to a point of repair has important readiness and cost implications:

- **Improved readiness.** Reverse logistics within the Army and the Department of Defense (DoD) has a direct impact on equipment readiness as well as on inventory investment.

The “transformed” Army will have a significantly smaller logistics footprint—especially when deployed. The evacuation of unserviceable reparables to a repair point will be important to expeditiously return key repair parts to serviceable condition in order to make them available to deployed soldiers.

- **More responsive sustainment.** With timely movement and collection of unserviceable parts at centralized repair points, there is less chance of interrupting repair flow because of a shortage of carcasses, i.e., unserviceable items that can be repaired.

A primary measure of supply chain effectiveness in DoD and in the Army is customer wait time (CWT), or how long the soldier customer has to wait until a needed part is delivered. The CWT metric links directly to how well the reverse logistics processes function—longer CWT can result in reduced readiness as well as higher supply and maintenance costs. Reverse logistics process performance, as it affects replenishment wait time (RWT), also drives inventory investment.

- **Less inventory investment.** If the “return to serviceable” time is shortened, more turnover of reparable assets is realized, and fewer are needed.
- **Better visibility and less overall clutter** within the system can result if unserviceables are moved expeditiously and consolidated at known locations. Item Managers (IM) can manage their reparable inventories with more precision and be more responsive to unexpected demands. This could be especially important for legacy and Army-unique systems for which there is no longer any manufacturing or commercial support; components and piece parts often have to be salvaged from unserviceable stocks with unknown or inconsistent washout rates.
- **Savings in transportation costs** are possible if forward and reverse pipelines can be integrated and synchronized from a system perspective versus treating individual items independently.
- **Financial incentives** such as credit policies, transportation fee structures, surcharges, etc. must necessarily align with and support decisions to improve the flow of unserviceable reparables to an endpoint.

Conclusion

Responsive repair capability plus timely and deliberate throughput are the keys to improved retrograde flows within the reverse logistics process. A broad range of activities needs to be examined, understood, and improved—beginning with timely turn-ins of unserviceable Class IX reparables, to redistribution of serviceable retrograde, to physical movement of retrograde, to in-transit visibility, and ultimately including the places of value recovery—repair shops and depots.

The Army should seek to integrate systems between levels—between forward and reverse processes and between organizations. Ultimately the focus needs to be on the soldier with equipment that needs to be supported—reverse logistics may be what he/she depends on for valuable and scarce replacement parts to support a fast-moving operation.

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Fort Hood personnel greatly facilitated understanding through their support of a detailed walk-through of many units in developing our “by-RIC” approach to the metrics.

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Acronyms and Symbols

A5A/A51	Materiel Release Order with NSN
A5J	Materiel Release Order – Shipment to DRMO
AMC	Army Materiel Command
AMDF	Army Master Data File
ASB	Aviation Support Battalion
ASL	Authorized Stockage Level
AWCF	Army Working Capital Fund
CASCOM	Combined Arms Support Command
Condition Code A	Serviceable
Condition Code F	Unserviceable-repairable
Condition Code H	Unserviceable-condemned
CONUS	Continental United States
CTASC	Corps Theatre Automatic [data processing] Service Center
CWT	Customer Wait time
D6A	Materiel Receipt – Returns
D6K	Materiel Receipt – Relocation of assets (from referrals/ redistribution)
D6M	Materiel Receipt – Returns from testing/repair
DA	Department of the Army
DIC	Document Identifier Code
DLA	Defense Logistics Agency
D-M-I	Define-Measure-Improve
DoD	Department of Defense

DOL	Director of Logistics
DRMO	Defense Reutilization and Marketing Office
DS	Direct Support
EUSA	Eighth U.S. Army (Korea)
FORSCOM	Forces Command (CONUS)
FSB	Forward Support Battalion
FTM	Materiel Returns Shipment Status
FTZ	Materiel Receipt Status – From Inventory Control Point to Customer
FY	Fiscal Year
GS	General Support
MACOM	Major Command
MRO	Materiel Release Order
MSB	Main Support Battalion
NIIN	National Item Identification Number
NSN	National Stock Number
OCONUS	Outside Continental United States
RF	Radio Frequency
RFID	Radio Frequency Identification Devices
RIC	Routing Identifier Code
RL	Reverse Logistics
RO	Requisitioning Objective
ROP	Reorder Point
RWT	Replenishment Wait Time
SAMS	Standard Army Maintenance System
SARSS	Standard Army Retail Supply System
SDP	Strategic Distribution Platform
SOR	Source of Repair
SORTS	Status of Resources and Training System
SSA	Supply Support Activity

SSF	Single Stock Fund
TMDE	Test, Measurement, and Diagnostic Equipment
TRADOC	Training and Doctrine Command
ULLS	Unit Level Logistics System
USAREUR	U.S. Army Europe
USARPAC	U.S. Army Pacific
VM	Velocity Management
XML	Maintenance Work Order created

Introduction

The Reverse Logistics Executive Council defines reverse logistics as “the process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal.”¹

Value recovery is an important focus of the Army reverse logistics (RL) pipeline, since component repair is the primary source of inventory replenishment for many expensive Army spare parts or secondary items. “Reparables” are important because they are intended to be their own source of future serviceable components. By definition, a “reparable” is an item that can be reconditioned or economically repaired for reuse when it becomes unserviceable. As part of a Level of Repair Analysis (LORA), the Army decides which parts should be repaired so that they can be used again (i.e., reparable) and which should be thrown away upon failure and replaced with a new part (i.e., consumables).² As such, reparable items are typically expensive investment items that should be expeditiously moved to repair points for repair/refurbishment/remanufacture to return them to serviceable stocks so as to minimize the amount of inventory investment.

In FY00, approximately 603,000 unserviceable reparable items conservatively valued at over \$1.9 billion flowed through the Army’s reverse pipeline,³ not counting the induction of unserviceable assets already in depot inventory to depot-level repair activities. As shown in Figure 1.1, these items had three primary dispositions: some

¹ Dr. Dale S. Rogers and Dr. Ronald S. Tibben-Lembke, *Going Backwards: Reverse Logistics Trends and Practices*, Reverse Logistics Executive Council, 1999, p. 2.

² The LORA is a two-stage process that considers both noneconomic and economic factors. Noneconomic factors include the design of the item/component, the feasibility of repair, the feasibility of a remove-and-replace repair strategy, the number and type of lower-level subassemblies, etc. The economic analysis considers the various elements that drive support cost, such as manpower, support equipment, training, transportation, and inventory costs. The goal is an optimized maintenance philosophy.

³ In comparison, the forward pipeline (no backorders) of Class IX parts for active Army Major Commands involved about 3 million requisitions valued at \$1.5 billion during this time period. The mean value of requisitioned items was \$516, with 75 percent of them valued at less than \$115 each.

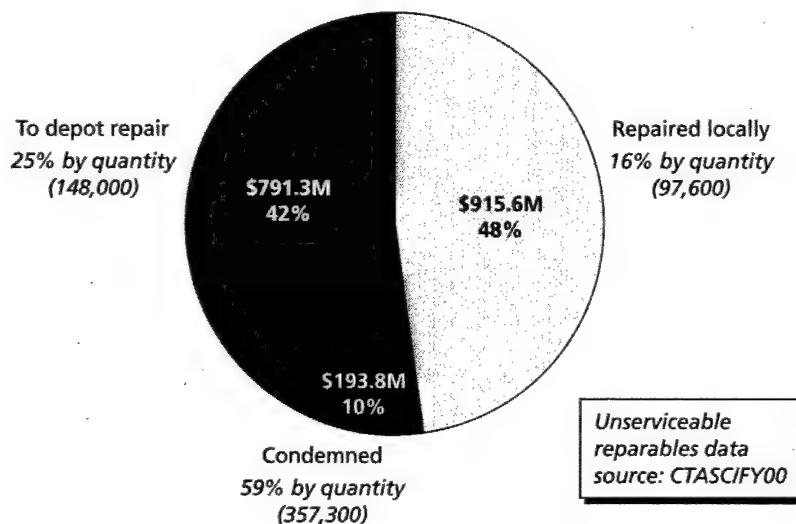
were repaired locally to be used again, some were disposed of as no longer useable or needed, and some were passed on to Army Materiel Command (AMC) depots for future refurbishment or remanufacturing.

Motivation for Improving Reverse Logistics Flows

The Army's Distribution Management (DM, formerly velocity management) initiative employs a structured Define-Measure-Improve (D-M-I) approach to improve processes. The most successful efforts under DM have focused on reducing the time a customer must wait for a needed part to be delivered through the forward logistics pipeline (i.e., customer wait time or CWT). In reverse logistics, velocity and consistency are still relevant, but "faster" might not be the guiding principle. Thus, for reference, we define improving the flow in the RL pipeline to mean *timely movement to minimize the amount of inventory investment*.⁴ In other words, the objective is to make the most cost-effective use of existing inventories.

Timely return of unserviceable carcasses to a point of repair has important readiness and cost implications.

Figure 1.1
Value and Disposition of Army Unserviceable Reparables in FY00



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⁴ This is not to imply that time is the only dimension where improvement efforts should be focused; there are also quality and cost implications for reverse as well as forward flows. However, as there are data to support the measurement of this aspect of the improvement effort, we begin with time as a focus.

Improved Readiness

The effectiveness and timeliness of retrograde flows and repairs of Army and Department of Defense (DoD) reparables has a direct impact on equipment readiness as well as on inventory investment.

The “transformed” Army will have a significantly smaller logistics footprint—especially when deployed. This will mean less repair capability forward as well as fewer spare parts forward. Replenishment through the forward logistics pipeline will be important, but so will the retrograde flow of unserviceable reparables to a repair point, allowing the expeditious return of key spare parts to serviceable condition so that they are available to deployed soldiers. The Army’s emerging maintenance concept is on-system repair forward (primarily component replacement), and off-system repair rear (primarily component repair); this concept is best enabled by a high-performance reverse logistics process, which helps assure availability of parts for on-system repairs.

More Responsive Sustainment

The potential for critical parts shortages occurring can be minimized with better visibility and management of the entire pipeline facilitated by better data collection and timely movement of unserviceable reparables. With the timely movement and collection of unserviceable parts at centralized repair points, there is less chance of interrupting repair flow because of a shortage of carcasses.

Ultimately, remanufacturing (repair) should be driven by customer demands. Serviceable reparables are issued from stock when a failure occurs, which, in turn, should signal the need for replenishment (perhaps not immediately) from a different echelon of serviceable stocks, a need to return the carcass of the reparable being replaced, and a need for another serviceable reparable to be generated at a repair point and shipped to the appropriate supply point.

A primary measure of supply chain effectiveness in DoD and the Army is customer wait time (CWT), or how long the soldier customer has to wait until a needed part is delivered. As its name implies, the metric is from the customer’s perspective: a maintenance organization needs a part or component, orders it from the supporting supply organization, and then waits until it is received. The customer is not concerned with where the part comes from, but rather with how long it takes to be delivered. The stockage of some parts relies for replenishment on the reverse pipeline, which is thus a key driver of CWT for some items.

Correspondingly, RL performance affects replenishment wait time (RWT), and as such, it also drives inventory investment for parts dependent upon repair for replenishment. RWT is measured from the perspective of supply organizations, which are responsible for meeting customer demands in a responsive manner. RWT is a measure of how long it takes to replenish or restock on-hand inventory.

Less Inventory Investment

If the “return to serviceable” time is shortened, more turnover of reparable assets is realized, and fewer are needed. This is significant from several different perspectives.

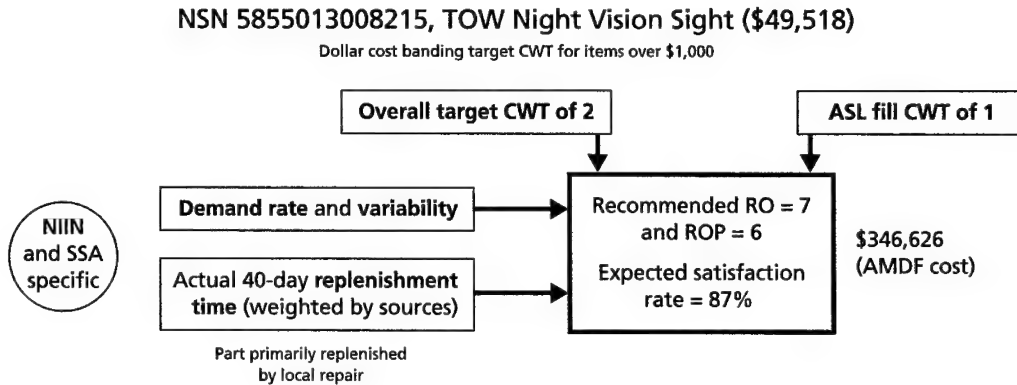
- Total investment dollars, where individual items such as turbine engines for an M1 tank cost around \$500,000 each, can be significantly affected by a reduction of even a relatively small quantity in stockage levels. Less inventory needs to be stocked “just in case” because of long RL pipeline times, which over time and for new part numbers reduces the quantity that must be purchased. A shorter RL pipeline equates to less inventory investment because the same set of reparables is used more often, i.e., turnover increases.
- There is less likelihood of damage and deterioration as fewer items are “stalled” or “lost” in the pipeline. There is a reduced chance that items will incur further damage from handling and/or insufficient packaging and protection. Also, because such damage can occur, delays can lead to the need to reinspect and reassess the condition of items, since the original assessment may no longer be valid. So additional (duplicative) costs can be incurred.

An Illustration of the Impact of Retrograde on Inventory Level

What and how much is stocked in local inventories is computed using various algorithms. Dollar cost banding is the recommended approach in the Army today.⁵ Once the dollar cost banding methodology recommends a particular part by National Stock Number (NSN) for stockage, the recommended depth is computed to provide a target service level expressed in terms of average CWT for that NSN for customers of that Supply Support Activity (SSA). The average CWT is a weighted average of the CWT for immediate fills from the supporting SSA and the CWT for all other sources of supply. In an example illustrated in Figure 1.2, given the NSN’s demand rate and variability, an authorized stockage level (ASL) fill CWT of 1 day, historical CWTs from all other sources of supply, and a historical 40-day replenishment time, it was determined that to achieve a target CWT of 2 days or better, the reorder point (ROP) should be 6 parts in stock and the requisitioning objective (RO) should be a quantity of 7 with an investment value of \$346,626. This is expected to result in a

⁵ Dollar cost banding expands the breadth of deployable inventories by enabling more critical small and inexpensive parts to meet the Army’s stockage criteria. The algorithm also uses customer service level goals that vary depending on the unit price of the item to set depth. Recommended stock levels are computed through iterative simulations against two years of actual demand history. Further details of dollar cost banding can be found in Kenneth Girardini et al., *Dollar Cost Banding: A New Algorithm for Computing Inventory Levels for Army SSAs*, Santa Monica, CA: RAND Corporation, MG-128-A, 2004.

Figure 1.2
Slow Replenishment Time Produces High Recommended Inventory



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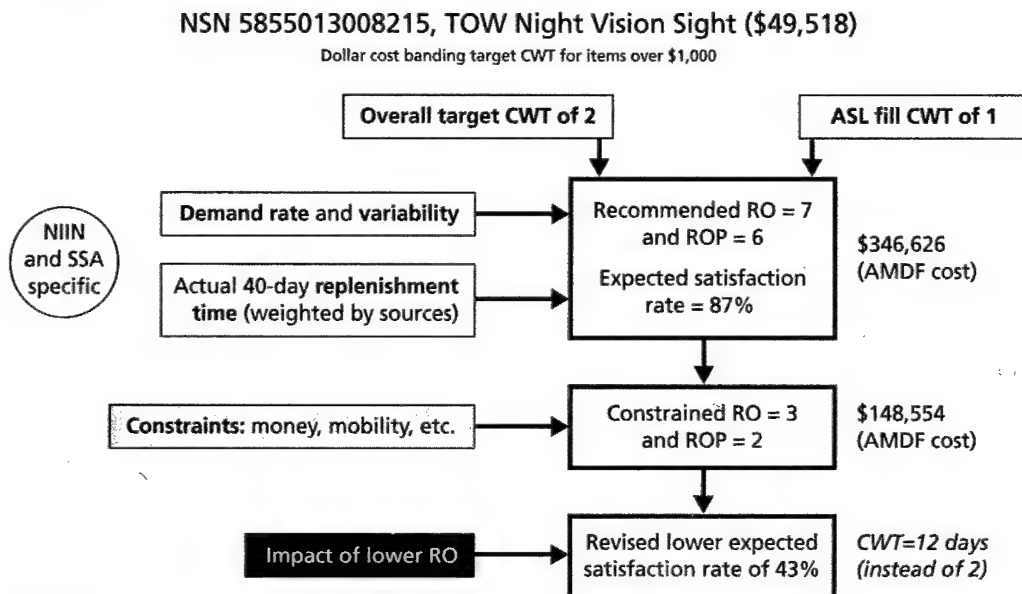
satisfaction rate⁶ of 87 percent, producing an average CWT of 2 days. We note that the bulk of stock replenishments for this item have been from the Direct Support (DS) repair shop in the SSA's associated maintenance activity in the same forward support battalion (FSB). Thus the RL pipeline time is driving the inventory depth requirement.

Other constraints like weight, volume, or budget often enter to reduce or limit a recommended RO. As depicted in Figure 1.3, it is likely that the high cost of the item (\$49,518 each) might result in a decision to reduce the recommended RO from 7 to 3 and the ROP from 6 to 2. This, in turn, will have an impact on the level of performance that can be expected (since fewer numbers of the item will be held in local inventory). The constrained RO leads to reduced performance, expressed here in terms of the satisfaction rate and CWT. The expected satisfaction rate drops from 87 percent to 43 percent, and the expected CWT increases from 2 to 12 days. Remember that these predictions are based on the historical replenishment time of 40 days. This means that instead of 87 percent of the requests for that NSN being filled from stock on hand, only 43 percent will be filled. Thus CWT will increase as more of the requests cannot be filled immediately from the ASL.

The opportunity and challenge now is to improve (i.e., reduce) the 40-day reverse pipeline time; holding the inventory depth constant, any improvement will increase the satisfaction rate. Possible improvements can come from a variety of sources, since the reverse pipeline time is a compilation of transit and processing times for the unserviceable repairable assets, as well as the physical repair time.

⁶ Satisfaction rate measures the depth of the ASL for NSNs that are stocked. It is the percentage of requests for items on the ASL that had sufficient quantity on hand to issue the total quantity requested.

Figure 1.3
Computed RO Quantities Are Not Always Affordable



RAND MG238-1.3

As continued in Figure 1.4, given the budget-constrained RO of 3, we can achieve a satisfaction rate of 87 percent if we can shorten the RL process to 12 days, i.e., some combination of reductions in transit, processing, and/or repair time. This resulting satisfaction rate would be the same as what we expected with the recommended RO of 7 and expected 40-day replenishment time. So there is a tradeoff for reparable stock: reduced RL times versus increased inventory levels/worse customer support.⁷

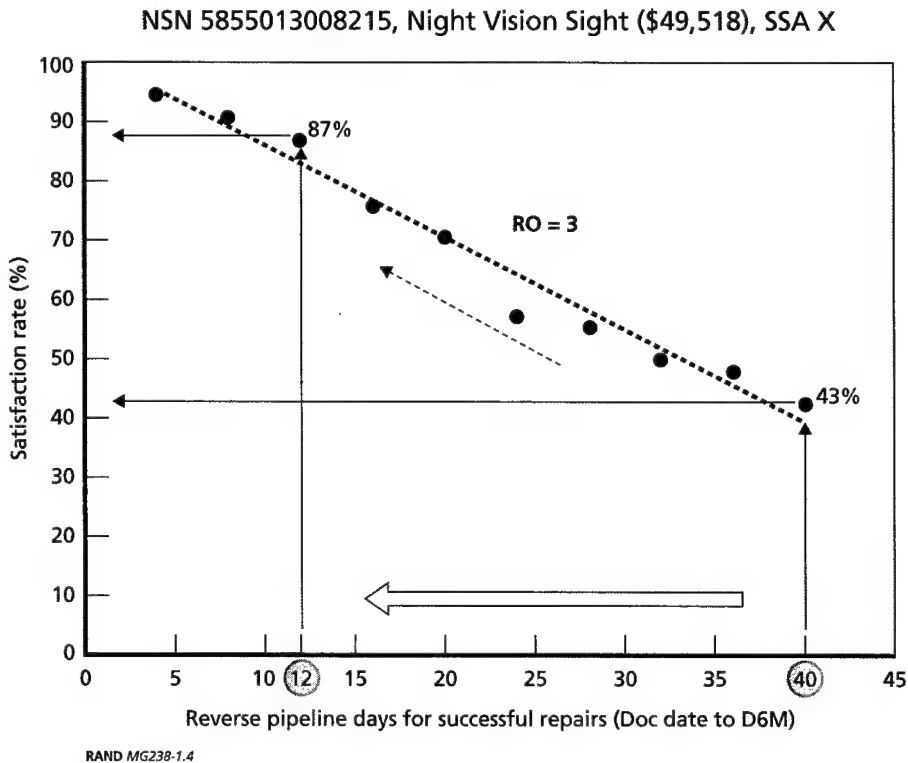
Next, in Figure 1.5 we add in the CWT line and see that a decrease in reverse pipeline days from 40 to 12 results in a CWT of 2 days, which was the original target.

Note that reducing the time to repair in this example by 28 days results in a savings of 4 items, negating the need for an additional \$198,000 in inventory investment, *or* the expected CWT is 10 days shorter, with fewer purchases from higher echelons of supply. The reduction in reverse pipeline days is predicated on a successful repair—with total time a combination of transit, processing, and repair times.

To summarize this example, we started with a target CWT of 2, which required an RO of 7; this in turn would yield an expected satisfaction rate of 87 percent. But

⁷ The other option is to rely not on local repair for replenishment but rather on wholesale inventory, which instead would rely on depot-level repair. This would buffer retail inventory against a slow, unreliable RL pipeline.

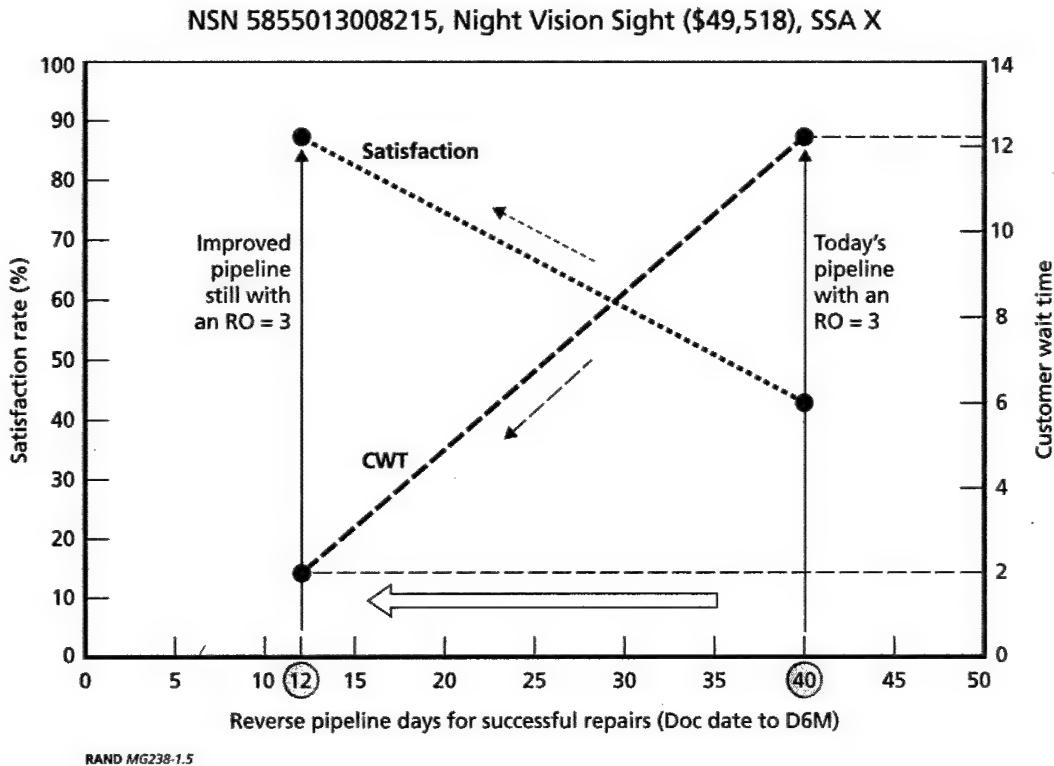
Figure 1.4
Decreasing Reverse Pipeline Time Could Improve Satisfaction Rate



we couldn't afford 7 items, so the RO was reduced to 3. To reach the same performance level for the RO of 7, we need to reduce RL days to 12. This is motivation to examine the RL process and improve it: reduced CWT with less inventory. In other cases, adequate space may not be available to stock the greater depth.

- **Better visibility and less overall clutter** within the system can result if unserviceables are moved expeditiously and consolidated at known locations. This would eliminate or reduce the perceived need to track every individual item because everything is moving expeditiously to an endpoint, i.e., condemned items to disposal and unserviceable (but repairable) carcasses to repair points specified for different types of materiel. With the visibility of unserviceable assets centralized at a few collection points, Item Managers (IM) could manage their repairable inventories with more precision and be more responsive to unexpected demands. This could be particularly important for older legacy or Army-unique systems that no longer have any manufacturing or commercial support; with these systems, components and piece parts often have to be salvaged from unserviceable items with unknown or inconsistent washout rates.

Figure 1.5
Satisfaction Rate and CWT Both Improve as Reverse Pipeline Time Decreases



- **Potential savings of transportation costs** may be achievable if forward and reverse pipelines can be integrated and synchronized from a system perspective versus treating individual items independently.

Establishing a process to move unserviceables routinely and regularly might produce sufficient volume for backhaul on scheduled channels, as is done with "forward pipeline" carriers through the Defense Distribution System (DDS), both in the United States and overseas. Unserviceable returns are often viewed as and shipped as individual items rather than a batch of items going to a central collection and sorting facility, which is commonly done in the commercial world.

Defense Logistics Agency (DLA) Strategic Distribution Platforms (SDPs) might function as distributors that sort and consolidate returns for delivery, with unserviceable stocks going to repair points.

A regular practice of linking to backhaul could promote a "sweep the floor" mentality to keep unserviceables moving. There would be no need to collect and hold items until a certain volume accumulated before arranging a shipment. This

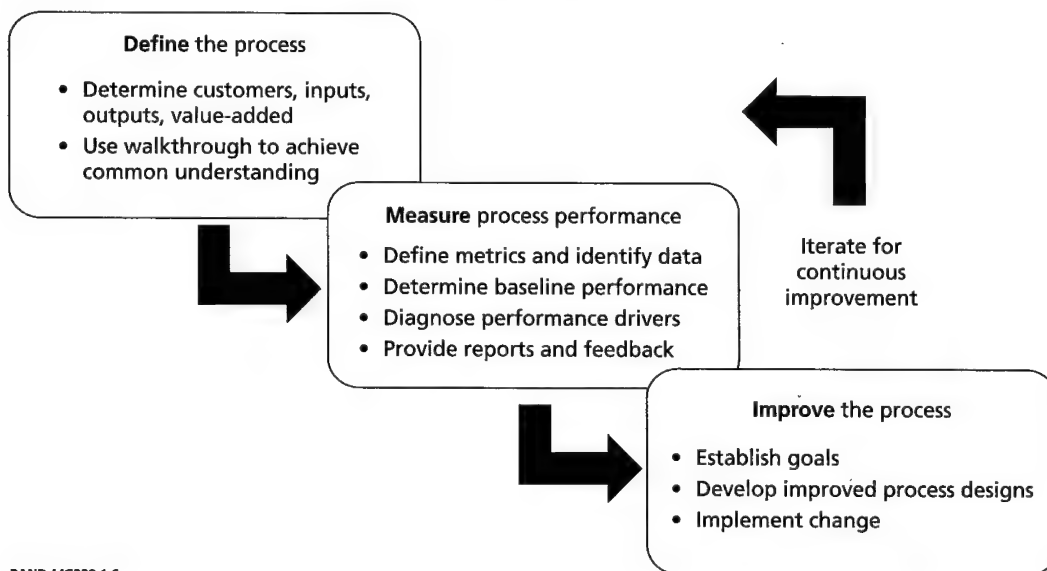
could reduce the management burden of coordinating transportation, reduce the space consumed by unserviceables, and make the return of unserviceables part of the daily standard process. Standard processes that are part of a routine are more likely to be done than “exception” processes.

Particularly for OCONUS, considerable time savings should also be achievable under this concept with the elimination/reduction of handling overseas.

The Define-Measure-Improve Methodology

The U.S. Army has successfully applied the Define-Measure-Improve (D-M-I) methodology to improve the *forward* movement of Army spare parts. Recently the Army began applying the D-M-I methodology to the *reverse* logistics (RL) pipeline. In this report we will use the D-M-I methodology (Figure 1.6) as an outline to discuss the characteristics and performance of the Army’s reverse pipeline. Specifically, we focus on unserviceable components and parts that are intended to be repaired and returned to stock for subsequent reissue and use. In Chapter Two we define and describe the Army’s RL processes and compare them to commercial/business practices. In Chapter Three we discuss metrics that can be used to evaluate how well the RL pipeline is performing. After discussing some initial improvement opportunities, we conclude in Chapter Four with implications for developing an improved RL pipeline for the transformed Army.

Figure 1.6
The D-M-I Methodology Leads to Continuous Improvement



Defining the Reverse Logistics Process

Reverse Logistics in the Commercial Business World

A predominant focus in the commercial retail sector with respect to reverse logistics (also referred to as the reverse supply chain) concerns a customer's return of unwanted merchandise. The customer need not be an individual—the customer could be a sales point, a distribution point, or a storage warehouse. Reasons for returns include not liking the product, the wrong item was ordered, a damaged or defective product, or a forecast error, among others. The company's focus is to collect the item, return money to the customer, and then “dispose” of the return as appropriate, e.g., return to serviceable stocks for resale, repair the item and return it to stock, send the product to a secondary market for sale at a lower price, dispose of it altogether, etc. Significantly, the returns process has typically been handled as separate and distinct from the forward supply chain. Recently, however, there has been more discussion of integrating the forward and reverse supply chains. This has been driven by factors that have recently made it more difficult to just throw away defective or returned items. These factors include significant increases in disposal costs, environmental laws concerning recycling and disposal, and the discovery by some companies that profits can be made in the reverse supply chain.¹

Some industries rely on returns of unserviceable carcasses for remanufacture and resale. Prime examples are automotive starters and alternators, where 90–95 percent of the items sold as repair parts have been rebuilt/remanufactured.² In this situation, carcasses for repair become important items for quick return in order to be remanufactured and put back on the shelf for resale. This is the model most similar to the Army's repair and reuse of reparable parts for its vast and diverse vehicle (wheeled and tracked) and aviation fleets.

In Europe, a much broader and encompassing perspective on the returns process has developed. Beginning with Germany, various countries have been looking at

¹ Thierry, Martijn, Marc Salomon, Jo Van Nunen, et al. “Strategic Issues in Product Recovery Management,” *California Management Review*, Vol. 37, No. 2, Winter 1995, p. 115.

² Rogers and Tibben-Lembke, p. 6.

the environmentally friendly disposal of packaging materials and have also extended disposal policies to include end products. Today many European companies are responsible for the disposal of packing materials after delivery of a product as well as the disassembly and recycling of product components at the end of the product's life cycle. By law, companies are required to take back these products and dispose of components. For example, automobile manufacturers must take back your no-longer-working automobile, disassemble it, and then appropriately dispose of materials—it cannot just be sent to the junkyard.

Overview of Differences: Forward Versus Reverse, Commercial Versus Army

This section provides a general overview of fundamental differences between forward and reverse supply chains or pipelines. Differences are briefly presented using the structure of Table 2.1, which is based on commercial practices. When appropriate, differences between the commercial world and the Army's environment are included.

Forecasting

As displayed in Table 2.1, there are fundamental differences that make the RL pipeline much more difficult to manage than the forward supply chain. As with customer demands in the forward supply chain, "demands" in the RL pipeline (i.e., unserviceable items) are generated in a random manner and thus can be difficult to forecast. However, the forecasting of returns is linked to and compounded by the uncertainties in the forecasts of the forward flows, typically encountered or seen as time lags in what happens in the forward chain. For example, holiday sales can be forecast with some degree of accuracy, but the magnitude and timing of returns from those sales is difficult to forecast. Although many turn-ins of unserviceable reparable lag the ordering of a replacement part, the lags may be significant and not readily recognized as being related.³

Transportation

As stated in Table 2.1, forward transportation of products typically is from one or a few sources to many retail destinations, while returns are typically the opposite; this is from a manufacturer's viewpoint. By contrast, an Army supply activity usually re-

³ The Army's forward pipeline for equipment repair parts is also difficult to forecast, with random and operational tempo-driven equipment and component failures. Although quite different from forecasting consumer retail demands in the private sector, "forecasting" would be less a problem if the RL process were improved in terms of speed, visibility, and standard procedures.

Table 2.1
Differences Between Forward and Reverse Logistics

Forward	Reverse
Forecasting relatively straightforward	Forecasting more difficult
One-to-many transportation	Many-to-one transportation
Product quality uniform	Product quality not uniform
Product packaging uniform	Product packaging often damaged
Destination/routing clear	Destination/routing unclear
Standardized channel	Exception driven
Disposition options clear	Disposition not clear
Pricing relatively uniform	Pricing dependent on many factors
Importance of speed recognized	Speed often not considered a priority
Forward distribution costs closely monitored by accounting systems	Reverse costs less directly visible
Inventory management consistent	Inventory management not consistent
Product life cycle manageable	Product life cycle issues more complex
Negotiation between parties straightforward	Negotiation complicated by additional considerations
Marketing methods well known	Marketing complicated by several factors
Real-time information readily available to track product	Visibility of process less transparent

SOURCE: R.S. Tibben-Lembke and D.S. Rogers, "Differences Between Forward and Reverse Logistics in a Retail Environment," *Supply Chain Management: An International Journal*, Vol. 7, No. 5, 2002, p. 276.

ceives forward supply chain deliveries in one location but may be required to send retrograde to multiple locations, depending on the item and its condition.⁴ Tibben-Lembke and Rogers⁵ point out that they are unaware of any implementation of a transportation system where forward and reverse shipments are combined. However, the Army and DoD have a unique opportunity to gain some synergy since, for the most part, the same network nodes and modes are used in both directions.

Quality, Routing, Disposition

Unserviceable returns require different levels of effort to determine what needs to be done and where. It is not simply a matter of sending an item routinely from point A to point B; the proper action will depend on the condition. Accompanying paperwork that helps identify the part, who is sending it, and what defect(s) have been diagnosed to date may be incomplete or missing. Thus, in RL there are product quality and disposition decisions that are nonuniform and so consume more time and effort.

⁴ A former Division Support Command (DISCOM) commander in Bosnia indicated that they had central receipt of forward materiel, but retrograde moved in about nine different transportation channels.

⁵ R.S. Tibben-Lembke and D.S. Rogers, "Differences Between Forward and Reverse Logistics in a Retail Environment," *Supply Chain Management: An International Journal*, Vol. 7, No. 5, 2002, p. 276.

Packaging

Packaging may be damaged or missing for returns, whereas this is less of a problem in forward shipments. Packaging design is a critical factor for easier and cheaper movement of large quantities in the forward chain; missing and/or improper packaging of fewer items causes more handling problems for returns. In the Army, packaging and cleaning are continual problem areas when unserviceable items are being returned. Heavy, bulky items must be protected from further damage; often, fluid leaks must also be dealt with. Even small items like circuit cards need to be protected from breakage and electromagnetic damage. Often the organizations returning unserviceable parts do not have adequate or appropriate packing and crating materials; many also have not been trained in packing and crating procedures.

Pricing

Another issue is the relative value of the items being turned in. For commercial returns, the quality of the returned item is a major factor, which magnifies the initial price differences found in the forward supply channels. With the implementation of the Single Stock Fund⁶ in the Army, credit policies have influenced turn-in procedures and local policies and, hence, retrograde workload uncertainties. This is over and above the basic issue of what value there is in a particular unserviceable item that might be recovered, and whether that value should be recovered.

Speed

Commercially, failure to deliver in a timely manner can result in lost sales and even lost customers. As a result, the speed of forward supply chains or channels certainly receives high-level attention in meeting customer demands in the retail world. For the Army, delays are not so much tied to lost customers, but they do affect the ability of units to train and achieve combat readiness. As a result, significant improvements have been made Army-wide in the forward logistics channel. However, a common attitude about items in the RL pipeline can be characterized by the phrase, "It's just a broken part." In other words, there is an apparent general lack of concern for moving unserviceable items to the place they can be repaired or disposed of. As Tibben-Lembke and Rogers point out, there is more potential for damage and obsolescence as returns clutter up the pipeline without reaching an endpoint.⁷ This also drives up

⁶ The Army's wholesale inventories of spare parts are financed by a "stock fund," which uses its income to pay for repairs and procurement of replacement parts. During FY01, the Army's stock funds were transitioned from separate wholesale and retail components to a Single Stock Fund (SSF). The change has also involved the transfer of some inventories that had been locally owned at the retail level to the financial control of wholesale logistics managers. For more information on SSF, see the publications by Brauner, Pint, Bondanella, Relles, and Steinberg (2000) and Pint, Brauner, Bondanella, Relles, and Steinberg (2002) listed in the bibliography.

⁷ Tibben-Lembke and Rogers, "Differences Between Forward and Reverse Logistics in a Retail Environment," p. 278.

inventory requirements and investment. Additionally, the Army has some unique equipment that has no civilian counterpart for support. This means that the timely return and repair of parts may be the only source of supply outside of lengthy and expensive new procurement, which is not a viable short-term alternative.

Costs

The nature and visibility of costs are another difference. RL has many impacts that may not be readily apparent, for example storage, handling, and inventory costs (especially if unserviceables are allowed to stop flowing and accumulate "midstream" without reaching an endpoint). Table 2.2 summarizes a comparison of reverse logistics costs and forward logistics costs by various activities/categories.

Inventory Management

Inventory management in RL channels is not consistent, and product life-cycle issues are more complex. The list of items that have a funded established repair line is set several years in advance and is not easily adjusted. This is exacerbated by lengthy and low-visibility RL flows, creating a difficult situation for item managers to flexibly manage (as currently structured).

Life Cycle, Negotiation, and Marketing

Life cycle, negotiation, and marketing are noted as being more complex in reverse logistics processes than in forward supply chains. Life cycles of Army reparables are long, as equipment replacement is an extended process and a wide range of equip-

Table 2.2
Comparison of Reverse Logistics Costs to Forward Logistics Costs

Cost	Comparison to Forward Logistics
Transportation	Greater: lower-volume channels
Inventory holding cost	Lower: lower-value items
Shrinkage (theft)	Much lower: limited use without repair
Obsolescence	May be higher: depends on delays
Collection	Much higher: less standardized
Sorting, quality diagnosis	Much greater: item-by-item
Handling	Much higher: nonstandard sizes and quantities; variable packaging
Refurbishment/repackaging	Significant for RL, nonexistent for forward
Change from book value	Significant for RL, nonexistent for forward

SOURCE: R.S. Tibben-Lembke and D.S. Rogers, "Differences Between Forward and Reverse Logistics in a Retail Environment," *Supply Chain Management: An International Journal*, Vol. 7, No. 5, p. 278.

ment is maintained for long periods, often beyond the time that commercial/industry support is available. Negotiation and marketing play relatively minor roles in comparison to the commercial world.

Visibility

Lastly, the Army's RL is less transparent than the forward logistics channels; this parallels the commercial world. The development and analysis of RL metrics could help make improvements in this area by capturing and reporting the performance of processes within the reverse logistics supply chain.

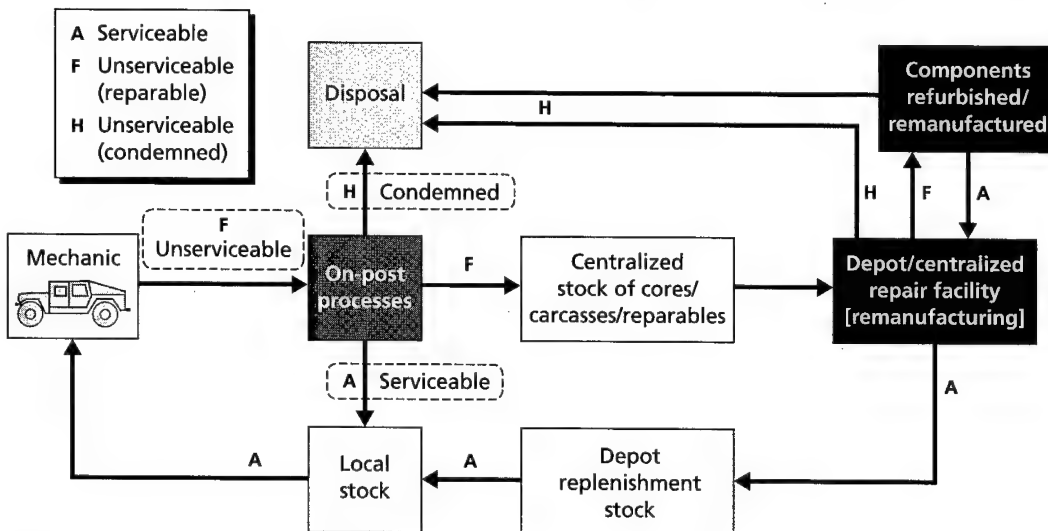
From an Army Perspective

In defining the Army's reverse logistics pipeline, we'll first focus on the return of unserviceable or broken parts by the customer, labeled as "mechanic" in Figure 2.1. The Army customer is typically a military mechanic who has identified a broken part on a piece of equipment, ordered a replacement part, and removed the unserviceable part for turn-in to the supporting Supply Support Activity (SSA).⁸ Typically there is a delay in removing the unserviceable part for turn-in until a serviceable replacement arrives. The SSA is the entry point to the box titled "on-post processing" in Figure 2.1, where a mechanic sends an unserviceable component, condition-coded F, for turn-in to the supply system. From the SSA, there are three general dispositions possible for a returned part. One possibility is disposal. This may occur when the part is determined to be no longer repairable, repair is no longer economically beneficial, or the item is no longer needed (i.e., obsolete or excess pieces exist); in these cases its condition code becomes H. Evaluation by maintenance technicians may or may not be involved, depending on the particular item and disposition rules. A second possible disposition is a maintenance action that returns a part to serviceable condition, i.e., its condition code is changed to A as a result of repair, recalibration, or refurbishment, and it is placed on the shelf ready to be issued to a customer. In Figure 2.1, this is labeled "local stock," a potential final disposition point after an unserviceable part flows through an on-post repair shop.

⁸ A good corresponding analogy in the business world is the field engineer who makes a service call to install or repair a piece of equipment. Blumberg estimates that 40–70 percent of all service calls require a part or parts to be replaced. Many of the replacement parts (close to 80 percent in terms of total investment) are high-value repairable items. These parts are removed, replaced with serviceable parts, and returned through RL channels to local or central repair depots; refurbished or reconditioned parts are restocked for reuse in the field. Donald F. Blumberg, "Strategic Analysis and Evaluation of Reverse Logistics Supply Chain in Approaches to Logistic Management and Control in High Technology Service Operation," *White Paper*, D.F. Blumberg & Associates, Inc., 2000.

Figure 2.1
Total Reverse Pipeline Depiction for the Army

Component condition "codes" change as parts move through the pipeline and are acted upon.



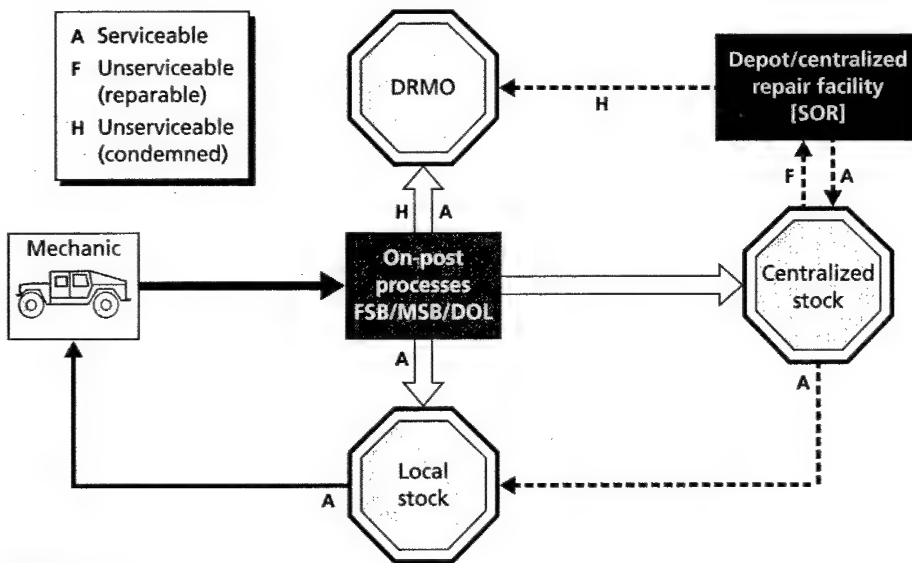
RAND MG238-2.1

These two general dispositions, disposal or return to stock, also occur at other locations for parts that are beyond the capability of local maintenance shops. This accounts for a third general disposition, which is shown in Figure 2.1 as an item that still has condition code F entering "centralized stock of cores/carcasses/reparables." These parts enter repair processes at depots or centralized repair facilities, where they are either disposed of or repaired and returned to stock. This includes a similar subprocess for components when assemblies are broken down into smaller components or parts that also may be repaired.

Because of the nature and complexity of the Army's depot repair processes, we will take a truncated view of the RL pipeline, one that focuses on flows from a local perspective. Thus we will not address the depot or centralized repair activities. This truncated view is shown in Figure 2.2. We should also note that the reverse logistics pipeline also handles the flow of serviceable items that are not needed, i.e., excess inventory. In this report, our focus is on the return and repair of unserviceable parts coded as reparable, which are generally relatively expensive. There is a wide range of excess serviceable parts that follow a similar process when they are turned in to the local supply activity by customers.⁹

⁹ Some would also include *referrals* in the RL flow because they are "redistributions" of serviceable "excess" at the local level. However, referrals are fundamentally different in that they are initiated by a customer demand that cannot be met by local stocks, thus the attempt to satisfy that demand from another post. The endpoint is a customer with a demand as compared to stock or repair process endpoints of the RL pipeline.

Figure 2.2
Reverse Flows Have Three Local Endpoints



RAND MG238-2.2

In Figure 2.2 the customer, typically the mechanic who works on a piece of equipment, turns an unserviceable item (or an excess serviceable item) into his/her unit supply system, where it flows through various local organizations until it reaches one of the three endpoints depicted in the shape of stop signs. If the item is serviceable or is returned to a serviceable condition by a local repair activity, it may be returned to local stock and thus be available for issue when demanded by a customer.

A second endpoint is the Defense Reutilization and Marketing Office (DRMO) or disposal. Reaching this endpoint means that the item cannot be repaired and is condemned, that it is not economical to repair and is to be discarded, or that it is not needed and not economical to ship elsewhere.

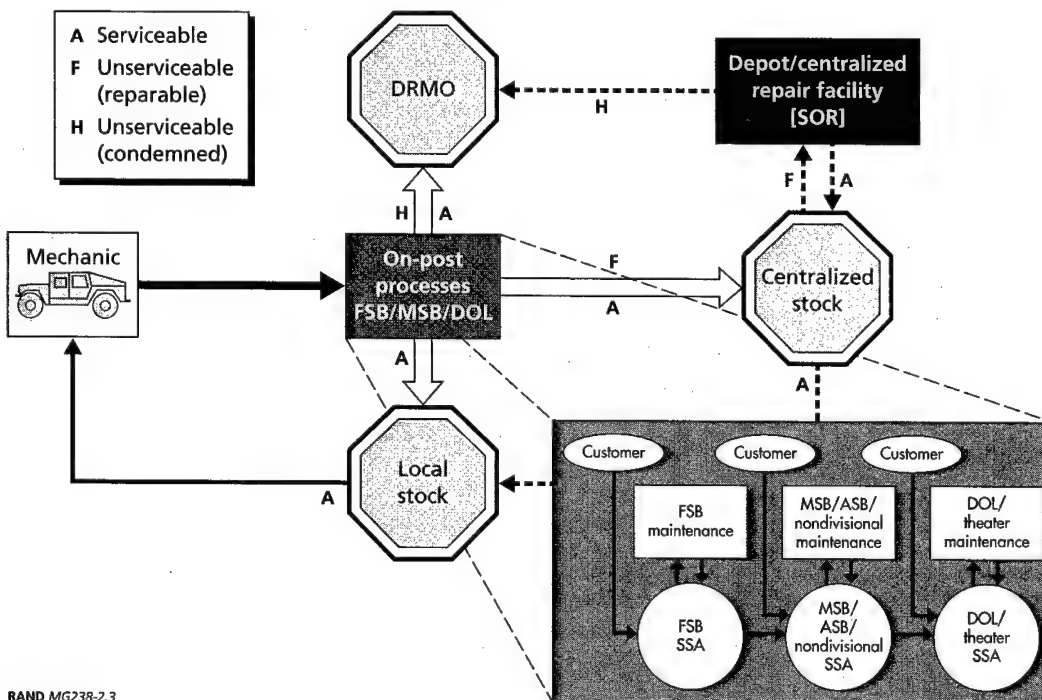
The third endpoint is a return that reaches centralized stock that is not part of locally owned stocks—either as a serviceable item or as an unserviceable reparable that will be centrally held until scheduled and input to a repair program. Centralized stock under Single Stock Fund (SSF) belongs to Army Materiel Command (AMC),¹⁰ and the location where stocks are held may be either on the local installation or in a supply warehouse at an AMC maintenance depot (for example, Anniston, Alabama, or Corpus Christi, Texas).

¹⁰ AMC has a diverse range of missions, from research and development of new weapons systems, to overhaul and maintenance of existing weapons systems in repair depots, to the wholesale distribution of spare parts to sustain soldiers throughout the world.

Although depot/centralized repairs are depicted on the chart, we will discuss flows only up to the supply warehouse that holds unserviceable assets for later induction into a repair activity. Thus we are truncating the total RL pipeline by excluding the time until induction into a depot repair program and the time to complete the repair; this is because once reparable items reach the depot level, carcass tracking (accountability) procedures change such that the linkage cannot be made between a carcass used in a depot repair or refurbishment action and its original return flow.¹¹

The box labeled “on-post processes” in Figure 2.2 actually represents a potentially complex series of flows through multiple echelons, as depicted in the blow-up in Figure 2.3. Customer returns may enter at various levels, whether to a Forward Support Battalion (FSB) (direct support or DS), a Main Support Battalion (MSB) or Aviation Support Battalion (ASB) (both are DS maintenance), or a general support (GS) maintenance activity at the Director of Logistics (DOL) facility on-post or a

Figure 2.3
Individual Flows at Local Level Are Varied and Complex



RAND MG238-2.3

¹¹ To provide insights into the overall RL pipeline, one would need to study depot-level repair processes separately without direct linkage to the processes that brought the items to the depot level.

theater-level operation designed to support units assigned to the theater.¹² The nature of the part, the complexity of the needed repair, special tools, test, measurement and diagnostic equipment (TMDE), skills/training, etc., and the type/level of unit will determine the route each follows; these considerations are addressed as part of the LORA described earlier. This highlights a primary difference between the forward pipeline/supply chain and the reverse: parts moving forward follow a defined, standard sequence. The reverse flow, however, is much more complex, with many possible routings for an individual part; we can identify and measure time segments for the possible flows, but we cannot say that a part follows the same routing all the time. Unserviceable reparables (and excess serviceables) begin the RL process when the initiating customer turns the part/materiel in to the SSA that supports the customer's organization.

From Figure 2.4 we see that there are three different points where a turn-in can be initiated. Exactly where a part *begins* the process depends on the type of organization and the location. The beginning or start time for a turn-in is the date entered on a document record created by maintenance personnel in the Unit Level Logistics System (ULLS) or in the Standard Army Maintenance System (SAMS).¹³ The maintenance unit next takes the document and the item to its supply support activity or SSA. Upon turn-in, the SSA processes the part, which includes creating a document record in the Army's automated supply system, called the Standard Army Retail Supply System or SARSS. SARSS indicates where to ship the item based on recoverability and maintenance codes as well as established repair programs. If the item is in the local repair program, the item is sent there and repair is attempted. If the repair is successful, the item is returned to local stock or is repositioned as a redistributable serviceable item. If the designated repair shop is not in the SSA's support battalion, it begins a transit process, which includes preparation for shipment, actual movement or transit to another location, and then receipt processing at the destination.

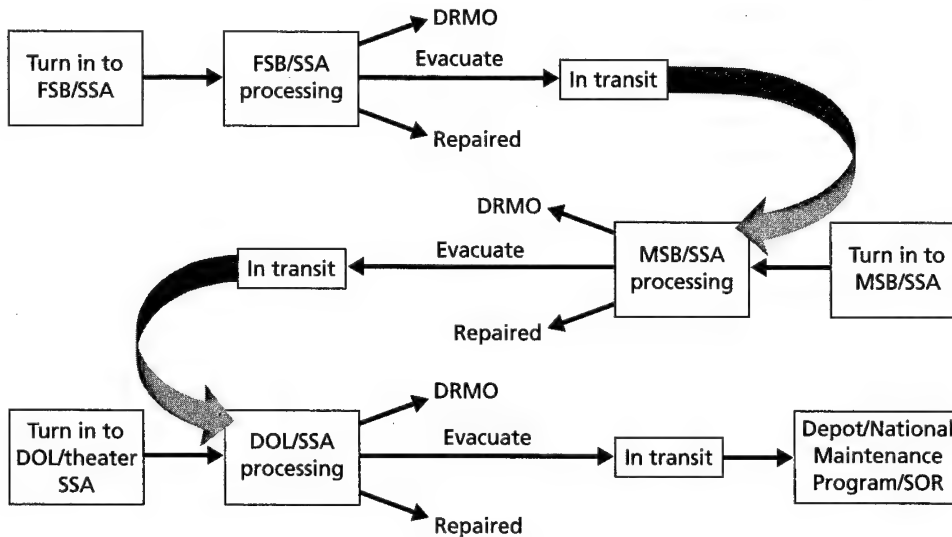
If an item cannot be repaired at a given location, it may be evacuated, i.e., passed on, to an echelon with greater repair capability. Again there is a transit process

¹² The current Army maintenance system consists of four levels of maintenance: unit or organizational (org), direct support (DS), general support (GS), and depot-level. They are characterized from organizational to depot-level by increasing levels of technical skill, increasing access to specialized tools and equipment, decreasing mobility, and increasing emphasis on sustainment versus a field/daily readiness orientation. The maintenance may be organic or contract activities. For more details on this four-level Army system, see the Appendix.

The Army uses maintenance allocation charts to designate the lowest authorized level of repair for each function on all types of repairs. Based upon this, capacity, and readiness needs, organizations designate which components each echelon of maintenance will repair. The supply computers automatically route carcasses accordingly.

¹³ ULLS covers organizational maintenance work order management, readiness reporting, dispatching, and vehicle history system (mileage, services, etc.). SAMS has two levels: Level 1 is the DS/GS work order management system, and Level 2 provides Materiel Management Center or MMC-level maintenance/fleet management reports.

Figure 2.4
RL Process for Unserviceable Reparables Can Be Generalized into Three Levels



RAND MG238-2.4

that includes several steps. If the item is determined to be unrepairable, uneconomical to repair, or uneconomical to return to another location, it may be disposed of, i.e., sent to DRMO.

Thus, at each organizational level there is a processing activity, followed by one of three possible dispositions: repair, disposal (DRMO), or evacuation. The remaining endpoint for our defined RL pipeline is the receipt processing by the supply activity associated with a repair activity at an AMC depot. We stop measuring at that point, since the document trail for a return ends and there is an indefinite wait before a part is inducted for actual repair at that echelon.

For ease of portrayal and general discussion of the RL pipeline, the flow has been depicted in Figure 2.4 as a linear flow or a series of end-to-end segments, similar to how the forward pipeline works. However, this is not true of the RL; it is much more complicated, with variable direction flows. Although there is much complexity in the RL flows and a lack of a standard process, we can focus improvement efforts on *processes* or *subprocesses* that underlie several distinct segments. In defining the RL process, we and what was then called the Combined Arms Support Command (CASCOM) Velocity Management team made several visits to Army units, both CONUS and OCONUS, to observe and understand how unserviceable retrograde is processed and moved through the RL pipeline. Below are some observations from those visits that indicate potential delays/bottlenecks—a natural starting place for improvement ideas.

Turn-In Process

Documentation required to turn in an unserviceable item often appears to be more than is actually needed or even used,¹⁴ while other information that might be useful is often not included.¹⁵ Unit personnel who begin the return process indicate that it can be a time-consuming task to gather and make copies of the documents required by their supporting supply activity. Without the documents (type and specified number of copies), they cannot turn in the item. Documents that are typically required include:

1. Turn-in document from the automated maintenance data system (ULLS/SAMS). This identifies the item by part number (NIIN) and includes a serviceability code (e.g., the code F identifies item as unserviceable but repairable; G indicates unserviceable and condemned).
2. Technical Inspection worksheet (Form 2404).
3. Photocopy of descriptive information from a catalog (the FEDLOG CD-ROM database of federal part numbers) for the part being turned in.
4. Serviceability tag. Identifies item as serviceable or unserviceable. All the information entered on the tag is also found on the turn-in document. The issue of who is authorized to create and sign the tag also arose; most times it appears to be signed by a supply clerk—not a technical expert who can determine the serviceability of the item.

If applicable, the following documents might also be required:

5. Drainage statement (3 copies).
6. Damage statement (3 copies).
7. Photocopy from Technical Manual showing a picture of the item.

Actual physical preparation of the item often appears to be time-consuming:

1. Items are required to be cleaned; by observation, this often is interpreted to mean “steam-cleaned.”
2. Items are required to be completely drained.
3. In some locations, items are required to be banded to a pallet (1 item per pallet, with the exception of track [32 per pallet] and road wheels [5 per pallet]).

¹⁴ When we walked the process followed by an unserviceable item, the processing personnel often indicated either that they didn't use certain documents or that the information was duplicated by one or more documents.

¹⁵ An example is information that might be useful for diagnosis and repair. It is not unusual for the documents to merely say “inop” or “broken” without further details of how the component malfunctioned.

Supply Support Activity (SSA) Processing

All of the initial paperwork from the mechanic turning in an unserviceable item is perpetuated at the SSA (FSB and MSB), plus 2 or 3 copies of the Materiel Release Order (MRO). It is not unusual for different SSAs on the same installation to independently set different requirements, such as the number of copies they want from the person turning in an item or the packaging requirement. However, since such a policy affects the subordinate organizations, the result is that the most stringent requirement becomes the standard for all organizations. When one SSA sets a requirement that may cascade through the chain of command, a central organization could evaluate the value of this action rather than simply allowing one organization's requirements (desires) to drive everyone else's.

We also observed that a number of items that are supposed to be disposed of at the lowest level¹⁶ are frequently turned in to the supply activity. This creates unnecessary work at both the unit and SSA.

We further noted that some DS-level repairable items are being returned for maintenance to the supply activity in condition code H (unserviceable-condemned). Rather than being disposed of directly to DRMO, the items are being recoded as F and turned in to a higher-echelon SSA. This creates unnecessary handling, workload, and a build-up of condition code H assets in wholesale-level inventory.¹⁷

When an unserviceable repairable item is turned in to a supply activity and entered into the automated data system (SARSS), there is a look-up table that indicates where that item is to be routed for repair. When those tables are inaccurate or out of date, items are incorrectly routed, thereby causing additional handling and delays. In a similar vein, time delays and unnecessary handling can be avoided when items are sent directly to where they are repaired rather than echelon-by-echelon; for example, if an unserviceable item is turned in at the FSB level and the required repair capability is located at the DOL, it should be sent directly to the DOL, not through the

¹⁶ These are coded "Z-Z" (Recoverability Code – Maintenance Repair Code), which means they can be thrown in the trash when unserviceable rather than processed through the supply system. An example is a seat cushion.

¹⁷ There are two issues in this situation. The first is that obvious scrap is sometimes turned in to the SSA from the customer level. These items were typically sent to maintenance and returned to the SSA in condition code H. At that point the SSA should send the item directly to DRMO but instead (incorrectly) interprets the regulatory guidance to say the SSA cannot do that and so recodes the items as unserviceable (condition code F) and sends them on to the Army Working Capital Fund (AWCF) SSA. The AWCF SSA does not automatically send them to DRMO; this action has to wait until an item manager directs it. The problem is the interpretation of the regulation and local policy; the SSA is allowed to turn in items directly to DRMO and should not send DS-level repairables or consumables to the next-higher level.

The second issue is that the AWCF should recognize these items and automatically send them to DRMO; the items should not have to wait until a manager reviews the AWCF's assets and recognizes that it has "scrap" and condemned items in stock.

MSB level (which processes the item through to the DOL without adding any value in terms of repair or disposal).^{18,19}

Some organizations, both maintenance and supply activities, indicate that higher echelons limit their turn-in to no more than 15 items (i.e., document numbers) daily. Numerical limits potentially restrict the turn-in of repair parts; if one has more than 15,²⁰ a choice must be made of which ones to turn in—often with little idea of which are most critical overall. Similarly, units sometimes are limited to certain days and/or hours when items can be turned in for processing.

Transit Process

Significant delays in moving unserviceable retrograde items were noted on walk-throughs. Examinations of paperwork for in-process unserviceable retrograde items commonly indicate that it had taken several days to move an item a very short geographical distance. Some of the delays are the result of practices discussed above. Delays also result from the practice of “batching”; unserviceables are sometimes accumulated until a certain amount is on hand before moving them on. In one case, delays were noted as a result of a supply clerk not having a driver’s license; he had to find someone with a license and a vehicle to transport him and the items to the supporting supply activity for turn-in.

Observations of outbound shipments from posts/installations suggest that some improvements are needed. A major issue is *packaging and crating*. For many reparable items this requires special materials as well as special training on how to properly protect items. Further, there may be environmental and hazardous material implications if items are moved via public transportation networks. Possible improvements might focus on whether to centralize this capability, who should do it, where it should be done, training issues, stocking of packing material, etc.

One could also examine the value of routing the redistribution of high-value items (CONUS as well as OCONUS) through DLA SDPs, since distribution is their core competence.²¹

¹⁸ In deployed/field operations this might not be feasible. It may be necessary to have a central turn-in or evacuation point where all unserviceables are processed and then sent to appropriate repair activities.

¹⁹ A significant time savings is potentially possible here. As will be seen later in the report, the FSB-to-DOL transit times tend to be much shorter than the sum of FSB-to-MSB and MSB-to-DOL transit times.

²⁰ Large numbers of turn-ins at one time may indicate that the unit is “batching” or collecting items before turning them in. This unnecessarily delays the RL process and should be avoided at the unit level.

²¹ The Defense Logistics Agency (DLA) is a U.S. Department of Defense (DoD) agency that provides worldwide logistics support for the military, certain federal agencies, foreign governments, international organizations, and others as authorized. Each of the 24 DLA distribution depots stores, issues, packs, preserves, and provides worldwide transportation of supplies and parts.

Two of the 24 distribution depots are called Strategic Distribution Platforms (SDPs): the Defense Distribution Depot San Joaquin, California (DDJC) and the Defense Distribution Depot Susquehanna, Pennsylvania

Maintenance Processing

While not a specific research focus in this effort, some general observations can be offered on maintenance and repair cycle activities. Movement of reparable to maintenance activities/shops (within the same echelon) by supply activities appears to be expeditious. Tables in the automated supply data system (SARSS) identify whether or not a reparable item can be repaired locally; if so, a work order (with a Document Identifier Code (DIC) of XML²²) is issued to transfer the item to a maintenance shop. If there is no local repair capability, SARSS data tables will indicate where to ship the item for repair, and the item is subsequently processed for shipment to that location.

Delays within maintenance shops need to be investigated more thoroughly as a separate research focus. However, it appears from this research that unserviceable items are sometimes batched at different steps in the repair process. For example, batching may occur when items are inducted into repair, i.e., the mechanic accumulates a number of items before beginning troubleshooting and repair. Sometimes repair backlogs occur because mechanics are assigned other jobs unrelated to maintenance. Batching also takes place at the end of the process. For example, repairs are attempted, items are tagged as to serviceability, and then the items are stacked on a pallet. Turn-in for further processing (e.g., return to stock, disposal, evacuation) is delayed until the pallet is full.²³

The entire process for condemned or condition code H items is not captured in our process diagram. We stop measuring when a return item is coded as condemned, and the rest of the process to move the item to DRMO is not captured. Superficial

(DDSP). These have primary regional customers including those overseas, where DDJC primarily serves the West Coast and Pacific region and DDSP primarily serves the eastern United States, Europe, and the Middle East.

²² DICs are DoD codes that identify processing actions. These codes are captured in automated data systems (e.g., SARSS) and indicate what actions are taken and the time (i.e., day) that action occurs. A series of DICs aligned in time order provide a data trail that can be used for process analysis. More about DICs and data collection will be found in Chapter Three.

The following are the primary DICs used in reverse flows:

D6A	Materiel Receipt – Returns
XML	Maintenance Work Order created
D6M	Materiel Receipt – Returns from testing/repair
A5A/A51	Materiel Release Order (MRO) for domestic shipment with NSN/MRO for overseas shipment with NSN
D6K	Materiel Receipt – Relocation of assets (from referrals/redistribution)
FTM	Materiel Returns Shipment Status (indicates item has been turned over to shipper for movement)

²³ One should note, too, that when we discuss measuring repair time in greater detail below, we end the process when there is an XML DIC *and* a corresponding D6M DIC (indicating a return from maintenance) *with* a serviceable condition code. What is difficult to measure for a particular item is how long it takes for that item, once repaired, to be returned to serviceable stock where it is available for issue.

observations indicate that there may be bottlenecks in this process as well. Concerns have also arisen as to what items are ending up in DRMO; for example, we know that items are sometimes retrieved from DRMO by Army personnel and even by commercial firms that later resell it to the government. This may be an area for future investigation.

Measuring the Reverse Logistics Process

An important purpose of measuring in the D-M-I methodology is to determine the level of performance, i.e., how well the process is done. The first objective is to establish a set of baseline metrics that can be used to communicate historical performance and future goals. Then as improvement efforts are initiated, one can use these metrics to objectively assess the success of specific improvements, as well as improvement over time.

In this chapter we first provide some observations on data processing, then provide some overall descriptive statistics of the Army RL system, and then conclude with RL metrics and the Army's historical performance using FY00 as a baseline.

Data Processing Observations

Our analysis is based on data contained in documents. While we would prefer to describe performance based on the flows of *materiel*, we must rely on the data in the documents. For that reason, observations and comments are based primarily on statistical analysis of the flow of *documents* within the RL pipeline.

When a returned item is first entered into an automated data system, it is assigned a document number that remains with it until it reaches a "reverse pipeline endpoint" and leaves the system. A document (number) tracks and processes only one type of item, i.e., only one National Item Identification Number (NIIN). The document number may, however, contain or account for multiple quantities of that particular item. For example, five identical batteries (i.e., all with the same NIIN) may be turned in using a single document. Rather than processing five separate documents, only one is used. However, for most Class IX unserviceables, the quantities per document are relatively small—typically one; Army-wide, 88 percent of all turn-in documents contain one item, as do 83 percent of documents ending in DRMO and 93 percent of documents recording a successful repair.

As an item (document) is processed through the RL pipeline, a DIC for different actions or events and the time at which the action/event occurred is recorded into the database for that document number. Thus, we can sort large amounts of data by

these unique document numbers, and then arrange the DICs in time order to reconstruct how that document was processed; this serves as a surrogate for how the item (possibly multiple quantities) was processed.

Since our analysis is based on “document flow” through the RL system rather than individual pieces, i.e., “materiel flow,” there are some general implications to be aware of. First, counts based on the number of documents usually understate the actual quantities involved because an individual document may contain more than one of that item.

The second general implication is that time statistics will tend to have some distortion. This is because the document is not processed, i.e., does not receive a time stamp, until the last piece is completed. For example, if five identical components are sent to a maintenance shop (one document, same part number), the processing time is calculated from the time of entry/receipt into the shop, and the end time is when the fifth repair is completed; the first through fourth repairs most likely took a shorter amount of time. However, if like parts are typically processed and handled in batches, then the time for the batch is more relevant than individual times.

Third, although we use document counts (versus total quantities), we can still estimate the dollar value of the RL pipeline by multiplying the part value (Army Master Data File (AMDF) price) by the quantity recorded on the document.

Overall Characteristics of the Army RL System

Before describing particular RL metrics, we next present some overall descriptive statistics and views of the overall Army RL system. Figure 3.1 characterizes workload within each organizational level (FSB/MSB/DOL-theater); workload is measured by the volume of RL documents reaching an endpoint at each level.¹ During the baseline period (FY00), most of the Army-wide RL workload² occurred at the MSB level (42 percent), and at the DOL/theater level (40 percent), with 18 percent at the FSB level.

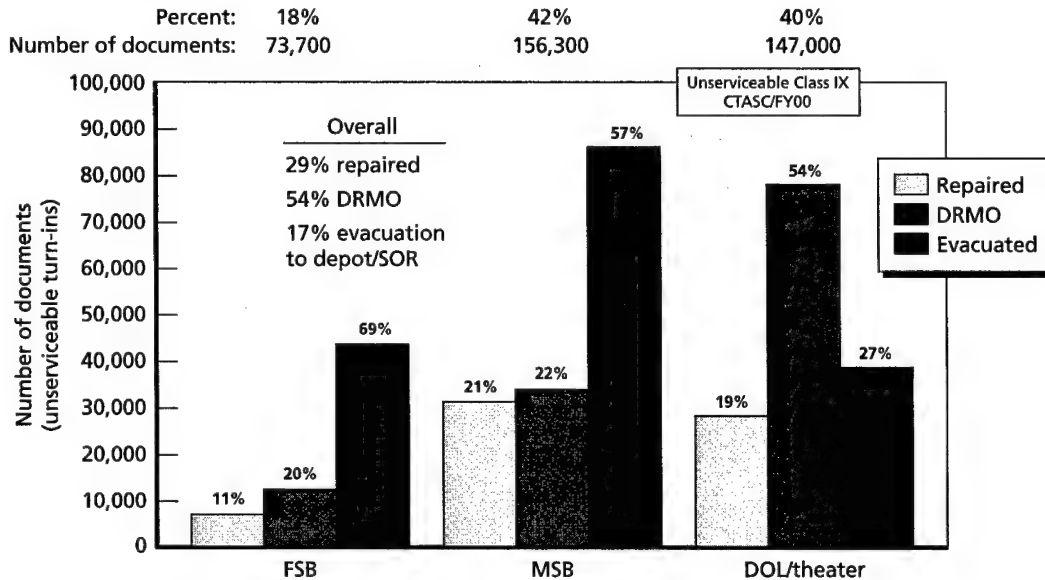
FSBs evacuate almost 70 percent of the unserviceable Class IX items (documents) turned in to them. Eleven percent are repaired by FSBs, with the remaining 20 percent condemned and sent to DRMO. This suggests that FSB improvements might best focus on processing and handling to move items onward quickly. Consideration should also be given to whether there should be any component repair at all at this level.

¹ Levels are not mutually exclusive. For example, an item (document) might be turned in to an FSB, processed, and then “evacuated” to an MSB where it is “repaired.” Thus, one document can (and often does) create workload at multiple levels.

² In this context, RL workload is measured by the volume of documents processed that pertain to unserviceable items.

Figure 3.1
Different Organizational Levels Have Different Workloads and Endpoints

Workload by level



NOTE: Levels are *not* mutually exclusive.

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MSBs also evacuate the majority of the items they handle—about 57 percent, although their repair capability is much higher than the FSB level. Interestingly, the DOL/theater-level processing of RL items (documents) resulted in over half going to DRMO (i.e., items were condemned) in the baseline period. The number of repairs is about the same as the MSB level. As the chart shows, 27 percent of items (documents) are evacuated from the DOL/theater level to AMC depots; this equated to over 38,000 documents during the baseline period.

When we look at the overall RL *system* with the three endpoints we defined, we see that 29 percent of the items (as measured by the number of documents) are repaired by FSB/MSB/DOL/theater maintenance shops. Over half (54 percent) are condemned and sent to DRMO, and 17 percent are evacuated to AMC depots.³

³ One should be aware that data are somewhat confounded between depot-level repairs and field repairs. The problem is that depot-level repairs are done at places other than AMC depots. For example, depot-level repairs of aircraft engines and other high-value items have been authorized at some DOLs and some theater-level repair activities. Current data collection and analysis does not enable us to distinguish DOL/theater repairs as being either depot-level or field-level. The result is that we understate the amount of depot-level activity in terms of value and quantity.

Figure 3.2
Repairs and Condemnations by Organizational Level

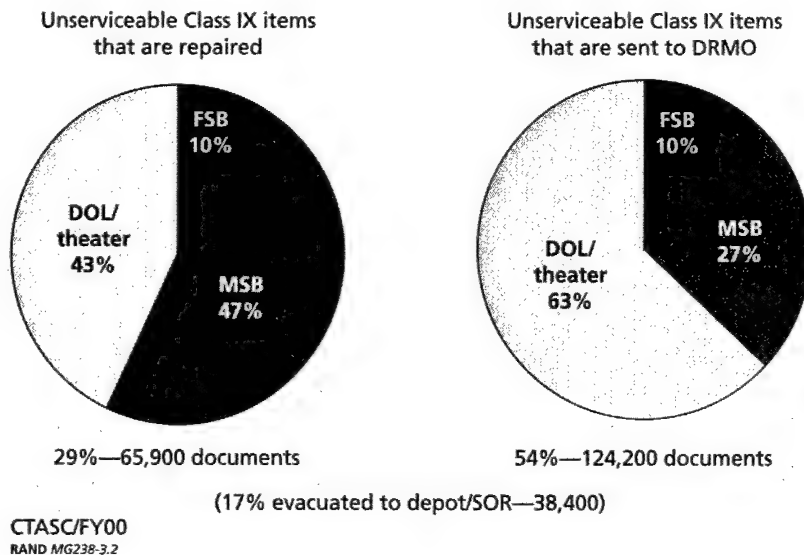


Figure 3.2 depicts repairs and condemnations in more detail. The largest number of repairs is accomplished at the MSB level, followed closely by DOL/theater repairs. We also see that most condemnations occur at the DOL/theater level. Because significant work (and cost) is involved in evacuating items that are subsequently condemned, it would be beneficial to eliminate these items at the lowest/earliest possible level where practical. We see that relatively little is repaired by FSBs based on the number of documents reaching that endpoint. We also note that relatively few items are condemned (another endpoint) at the FSB level.

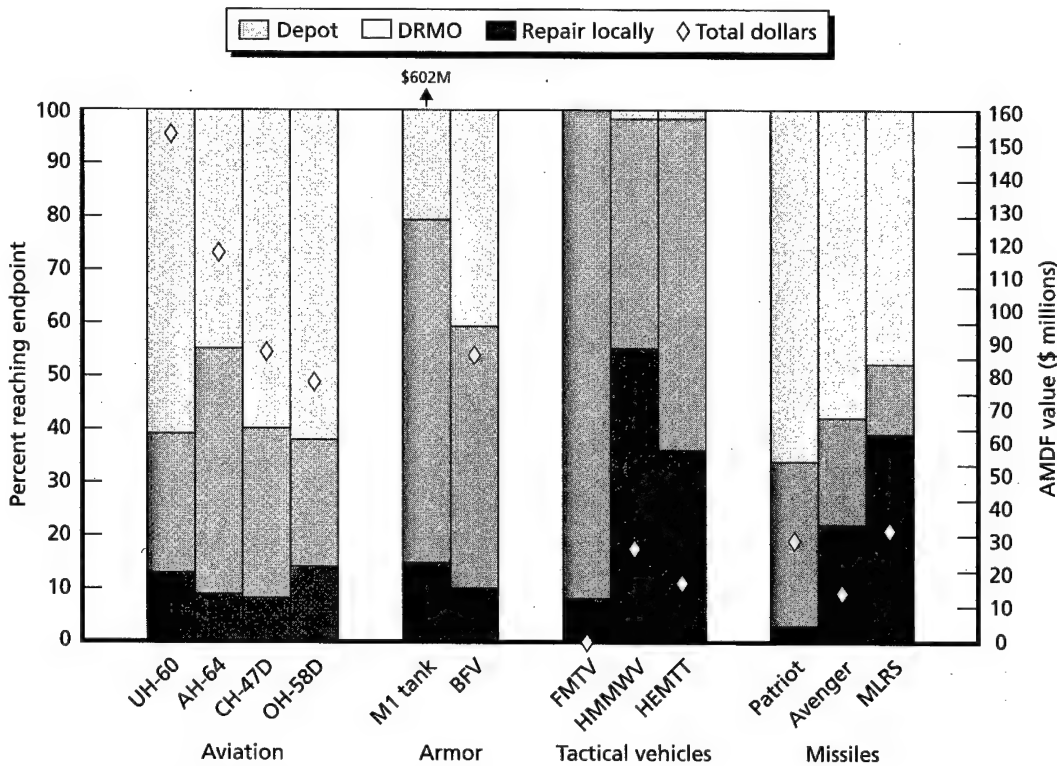
The following figures present a more detailed look into the characteristics of unserviceables that reached each of the endpoints, i.e., (1) repaired locally (FSB/MSB/DOL or theater); (2) condemned and sent to DRMO; or (3) evacuated to AMC depot supply activity.

Figure 3.3 depicts the value and disposition of unserviceable items by different weapon systems;⁴ using Army Materiel Category (MATCAT) codes⁵ we can link in-

⁴ This figure is intended to capture general observations on total value and disposition in the reverse pipeline of different equipment types. Readers should be careful with interpretation and comparison. In particular, one should note that total value is a function of quantity as well as unit price—one or the other or both could be the underlying driver of differences between weapon systems. Likewise, costs are not allocated uniformly across the disposition percentages. For example, from the figure, about 65 percent of M1 documents reflect a DRMO endpoint, but that doesn't mean that 65 percent of the total value was disposed of.

⁵ Materiel Category (MATCAT) code is a five-position code that links a specific part to the weapon system it is used on. There are varying degrees of detail and specificity depending on the type of part (unique or general) or the combination of the five positions one uses.

Figure 3.3
Selected Weapon Systems Vary by Endpoints and Overall Value



NOTE: Percentage of turn-ins, not value.

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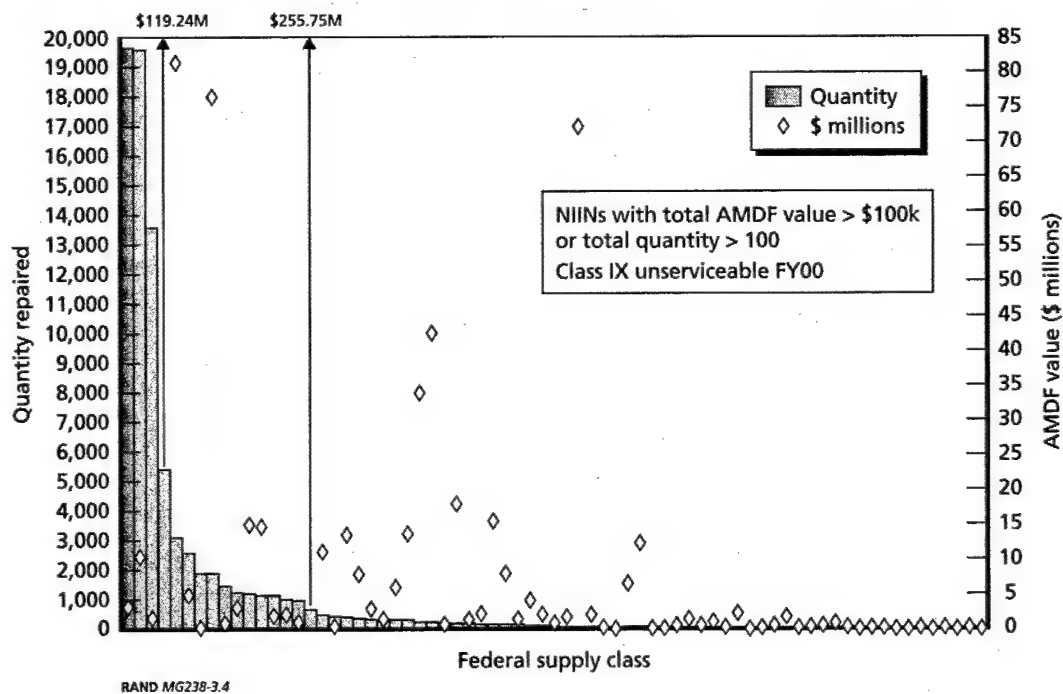
dividual part numbers to the weapon system they are used on. (Note: this is not a perfect process, as many parts are coded as “common” to multiple weapon systems, but this is less prevalent for reparable.) Figure 3.3 depicts major systems that are tracked at DA level for readiness reporting, i.e., known as SORTS (Status of Resources and Training System) systems. They have been grouped left to right by aviation, armor, tactical vehicles, and missiles.

- **Aviation.** Most aviation parts are sent to depot level, although 8–15 percent are repaired locally, and 20+ percent are sent to DRMO. We also note that aviation parts are relatively expensive, leading to a relatively high dollar value of returns in aggregate.
- **Armor.** Values for the M1 tank dominate all other weapon systems as the result of high quantities combined with relatively expensive part prices. Some local repairs are noted, there is more DRMO activity than with aviation, and there is some depot-level activity.

- **Tactical vehicles.** Very little depot-level activity is seen here. These are relatively low-value items that are either repaired locally or condemned. (Note: The absence of depot activity for FMTV happens because these are under warranty, and contract repair covers repair at that level. Also, much of the depot-level repair activity for HMMWV and HEMTT is likely done by authorized DOLs rather than depots.)
- **Missiles.** Depot-level repair activity is predominant and similar to aviation. However, the total values, driven by lower volumes, are lower, with more local repair in general.

The next set of figures examines each of the endpoints by Federal Supply Class (FSC).⁶ Figure 3.4 depicts those items that were repaired at FSB, MSB, DOL, or theater; in other words, repairs that were accomplished at other than AMC depots. Individual parts with cumulative AMDF values over \$100,000 or with more than 100 items repaired were sorted by their FSC and plotted left to right in decreasing quantities; corresponding AMDF values are also plotted for each FSC.

Figure 3.4
Value and Quantity of Items Repaired by Federal Supply Class

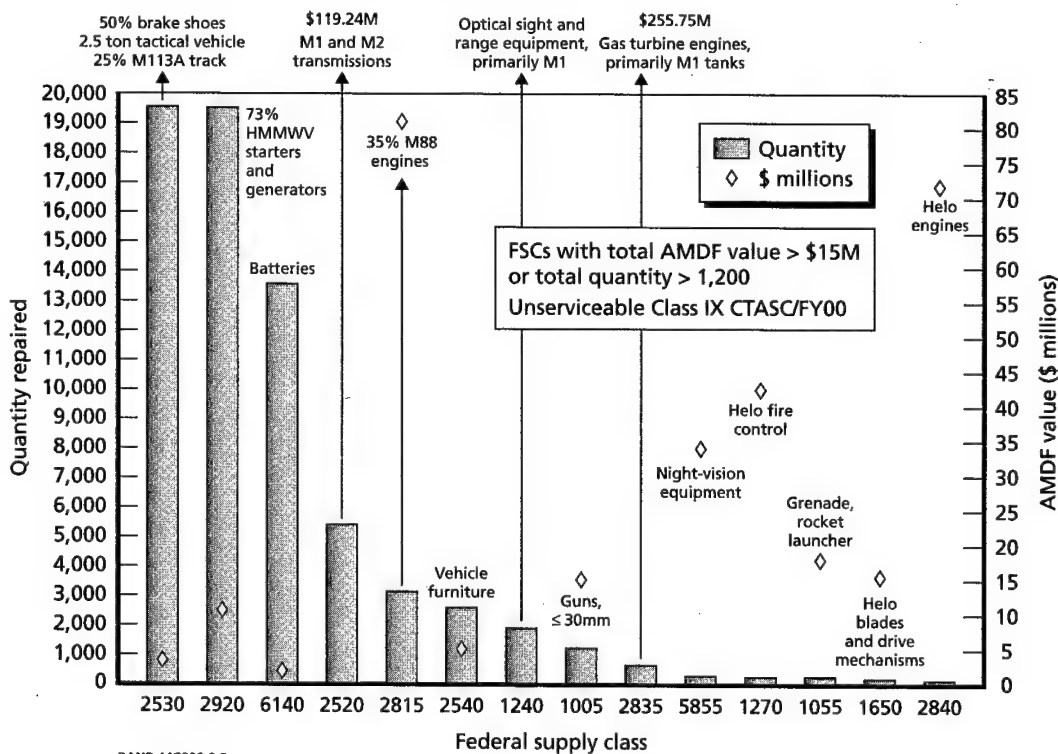


⁶ A Federal Supply Class (FSC) is a combination of four numbers that describe the commodity class of an item of supply.

As is apparent in Figure 3.4, there are many FSCs with both low quantities and low dollar values that were repaired. But as noted earlier, the total AMDF value for the endpoint was over \$915 million. In Figure 3.5 we exclude the low-dollar and low-quantity FSCs to better characterize the major items that are repaired below depot level.

Figure 3.5 portrays only FSCs that have a total AMDF value of unserviceable returns greater than \$15 million or that have total quantities greater than 1,200, leaving 14 FSCs as the primary determinants of value and/or quantity of items repaired. High-value repairs are dominated by M1 tank engines, which have unit prices of around \$500,000. Other high-value repairs are M1 and M2 transmissions, and M88 and helicopter engines. Optical sight and range equipment, night-vision equipment, helicopter avionics, and helicopter blades are also high-value repair items. In terms of quantity, three types of items dominate the repair portion of the RL pipeline: brake shoes/track, HMMWV starters/generators, and batteries; all are relatively low-value.

Figure 3.5
High-Value/High-Volume Repairs at FSB, MSB, DOL/Theater

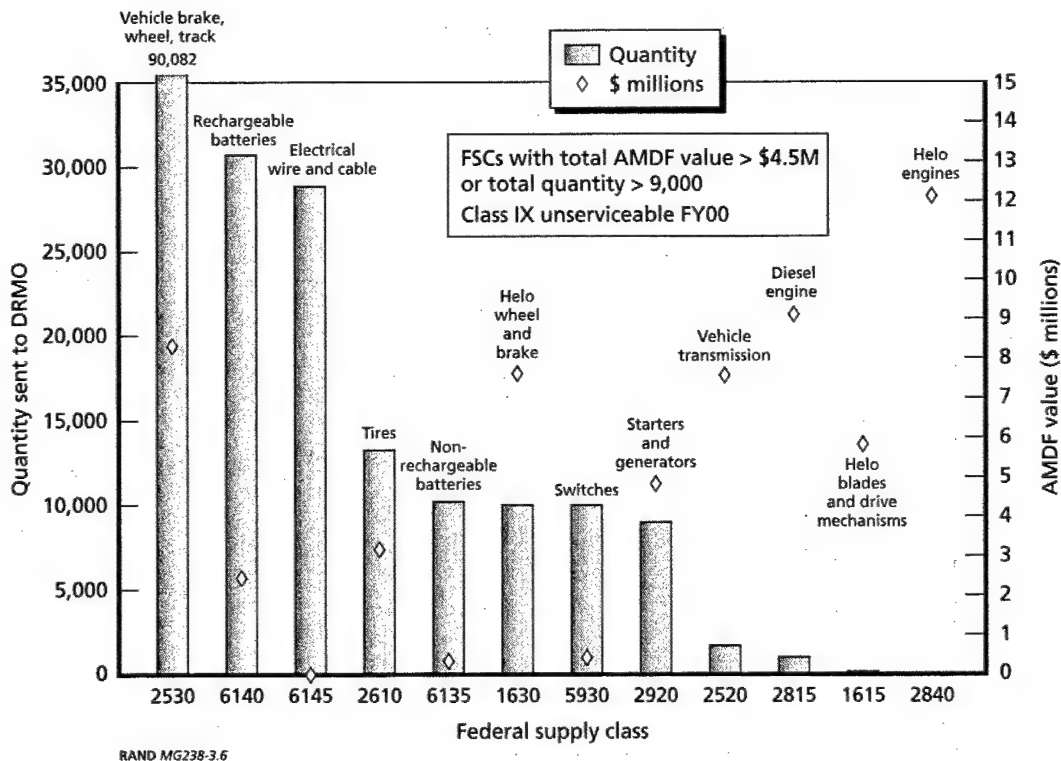


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Figure 3.6 depicts items that went to DRMO; note that we include only FSCs with total values greater than \$4.5 million or total quantities greater than 9,000. It is also important to note the increased scale on the left-hand axis (going up to 35,000 items) and the reduced cost scale on the right-hand axis (maximum of \$15 million). As stated earlier, many items reached the DRMO endpoint but were relatively low-value overall. Quantities are greatly dominated by vehicle brake parts, wheels, and track parts. Significant volumes of rechargeable batteries and electric wire and cables were also condemned. On the right-hand side we note that some small quantities of individually high-value items were disposed of; these included vehicle transmissions, diesel engines, helicopter engines, and helicopter blades.⁷

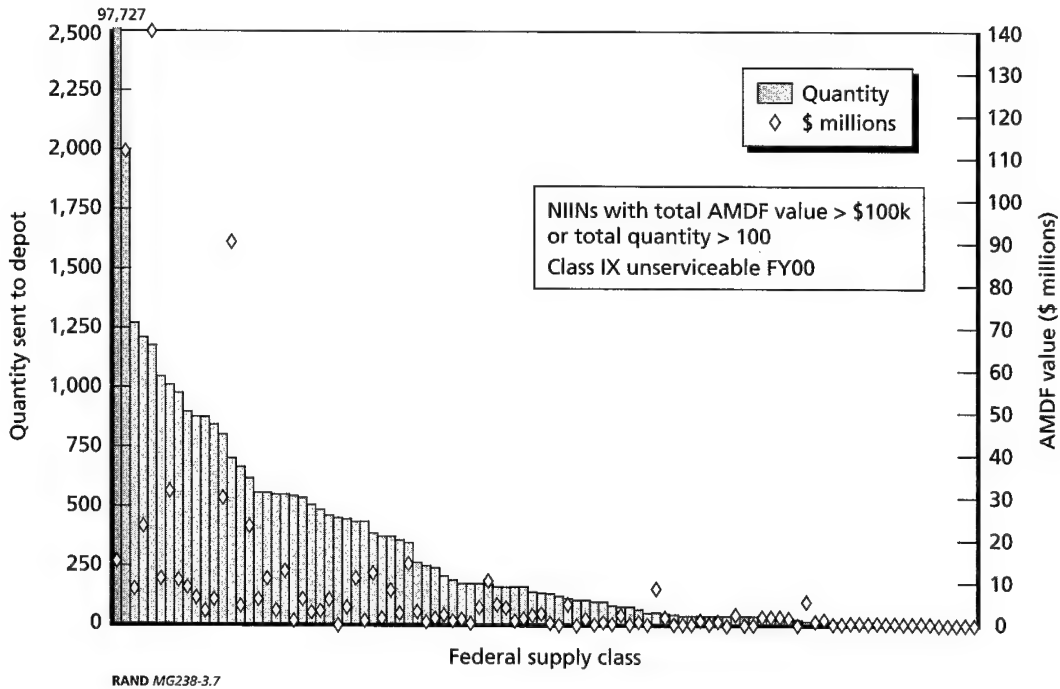
Figure 3.7 depicts a large breadth of unserviceables sent to AMC depots; note that this includes a wide variety of components as characterized by the large number

Figure 3.6
High-Value/High-Volume Items Sent to DRMO



⁷ This is further evidence of depot-level work being done at echelons below depot; high-value items can normally only be condemned by an activity authorized to perform depot-level repairs. As stated earlier, these activities are probably DOLs that are in fact authorized to do that level of repair, but whose data are currently confounded with field repair activities.

Figure 3.7
Value and Quantity of Items Sent to AMC Depots

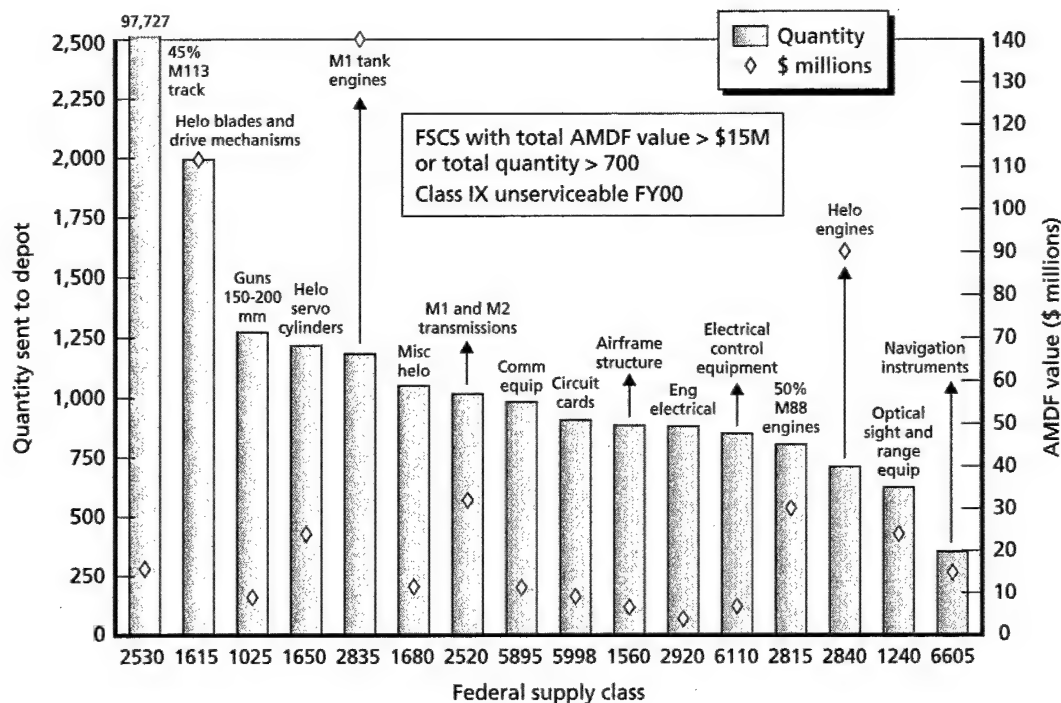


of FSCs. Total value is significant in several FSCs, with a single FSC dominating quantity. Figure 3.8 expands Figure 3.7 by focusing on the high-aggregate-value/high-volume FSCs; FSCs with total AMDF values less than \$15 million and total quantities less than 700 have been excluded. First we note that quantities in this segment of the RL pipeline are huge for one FSC—the one for track—and that it is predominantly M113 track; while of relatively low value, it does represent significant workload and transportation cost. Value is significant in several FSCs: M1 tank engines, helicopter blades, and helicopter engines. Other high-value items include M1 and M2 transmissions, M88 engines, helicopter servo cylinders, and optical sight and range equipment.

Collecting Data and Identifying Process Segments

In this section, we first look at the process data that were available from Army data systems and then define data measurements for specific process segments; these correspond with previous depictions and discussions of the RL pipeline. Then we portray a general “end-to-end” series of measurements that will comprise a basic RL metric format, which is used to portray RL performance from an overall Army perspective.

Figure 3.8
High-Value/High-Volume FSCs Sent to AMC Depots



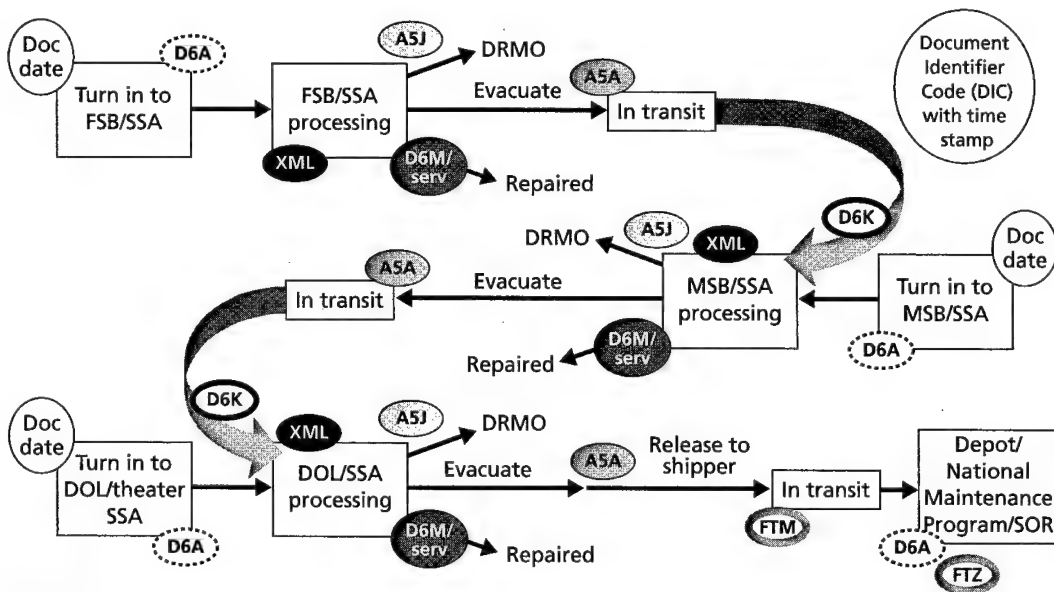
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Data from the Corps Theatre Automatic Service Center (CTASC) can be used to define and measure various time segments. Essentially, these data are a series of DICs⁸ that were entered into SARSS as the turn-in item was processed and moved, or as its condition or status changed. When a DIC is entered into the database, there is a corresponding time stamp that records when the change in DIC occurred. In Figure 3.9, DICs relevant to the RL pipeline have been inserted into the process flowchart shown earlier; as can be seen, there are three more or less congruent levels (i.e., FSB, MSB, and DOL or theater for OCONUS MACOMs) where DICs are repeated. The “doc date” bubbles in the figure indicate three independent starting points for a retrograde item.

By compiling all the DICs for each unique document number in the CTASC database, we can construct the time-sequenced path each particular part followed and determine how much time was spent between any pair of nodes in the process. Such measurements can be associated with various process segments of interest, as shown in Table 3.1.

⁸ See page 25, footnote 22, for details of DICs used in reverse flows.

Figure 3.9
CTASC Time Stamps and Document Identifier Codes Allow Measurement of Time Segments



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Table 3.1 shows processes pertinent to the RL pipeline and the pairing of DICs that are used to measure those processes (i.e., by calculating the difference in time between the time stamps associated with that pair). From this table, as well as from previous process depictions, we note that processes tend to recur at different organizational levels, i.e., FSB, MSB, and DOL/theater. Key process segments include the customer turn-in process, SSA processing to determine disposition of an unserviceable item (i.e., repair, disposal, or evacuation to a higher level), and the transit process that moves return items between levels.

With more pervasive use of radio frequency (RF) technology, future data collection could reflect a further subdivision of the in-transit segments. By putting RF tags⁹ on retrograde shipments, RF interrogators record additional time stamps as RL shipments physically move through the system. These additional data would allow additional (sub)segment measurements to help identify more specific transportation/movement-related activities that may require improvement efforts, such as:

- A5A-to-RF tag creation for shipment (processing/preparation time)
- Tag creation-to-physical departure (time awaiting transportation)

⁹ Also known as Radio Frequency Identification Devices (RFID). There is still no common commercial protocol. U.S. Army Europe (USAREUR) has a standard of using RF tags on at least 90 percent of retrograde shipments from SSAs that have equipment to "burn" or write data onto RF tags. USAREUR's retrograde volume and its central processing before return to CONUS provide increased incentive to have more visibility of the in-transit segments.

- Departure-to-arrival at destination (actual transportation time)
- Arrival time-to-D6K receipt (time to receipt and in-process item)

There are a number of statistical issues to understand as we measure these segments. In particular, it is important to understand the underlying populations. Each document number and its associated DICs and time stamps create a unique flow. Since we have a wide variety of flow sequences with intersecting or overlapping process segments, each defined time segment (and the metric developed to describe it) has its own population, which may be very different from the segments on either side of it in the general process flow. In other words, there will be a different mix of observations for each segment (metric), which also means different population sizes (number of observations used to calculate metrics). This means we cannot, with any real degree of meaning, add individual segments together to statistically draw conclusions about the larger process or sequence. However, we can draw statistical conclusions about each segment independently (given a reasonably large number of observations) and thus statistically valid conclusions about the population that passes through it.

The concept of “missing data” in this analysis is elusive. First, in the largest sense the RL population begins with every item returned. Of those, our interest lies only in the population of Class IX reparable items. We immediately pare this down further to the subset of all returned items that “completed” the reverse/return process (i.e., were repaired, were condemned, or arrived at a depot or centralized repair activity) during a specified time period (e.g., for this report FY00 is the period of interest).

Table 3.1
Key RL Process Times Can Be Measured as Differences of DIC Time Stamps

Process Description	Level of Activity	DIC Time Stamps (End Time Minus Start Time)
Customer turn-in	FSB/MSB/DOL	D6A – Document date
SSA processing (item evacuated to higher level)	FSB/MSB/DOL	A5A – D6A/K
Repair (make serviceable)	FSB/MSB/DOL	D6M (w/serviceable condition code) – XML
Condemnation (send item to DRMO)	FSB/MSB/DOL	A5J – D6A
Move item to higher level (local transit)	FSB-to-MSB FSB-to-DOL/theater MSB-to-DOL/theater	D6K – A5A
Release to shipper	DOL/theater	FTM – A5A
Move item to depot/source of repair (SOR) supply activity	DOL/theater	D6A – FTM or FTZ – FTM

In calculating differences between two time stamps to estimate the processing time for the activity bracketed by those time stamps, it is important to note that we only have a valid data point or observation when we have both time stamps, i.e., a “start” time and a “stop” time. If one or both time stamps is missing, we cannot compute a measurement to enter into the analysis. Further, returns enter the process at different echelons, follow different pathways, and receive final disposition at different points in the process (i.e., items are repaired or sent to DRMO). So although we begin with a very large set of documents, there can be a much smaller set of observations to measure the various segments.

The reasons for missing time stamps are difficult to assess.¹⁰ Most reasons are a form of inaccurate data collection: missing entries, entries with errors, entries that create logical disconnects (e.g., end time is earlier than start time), and so on. However, it is common for data quality to improve when metrics are created and management attention is focused on process improvement.

Developing a Metric Format

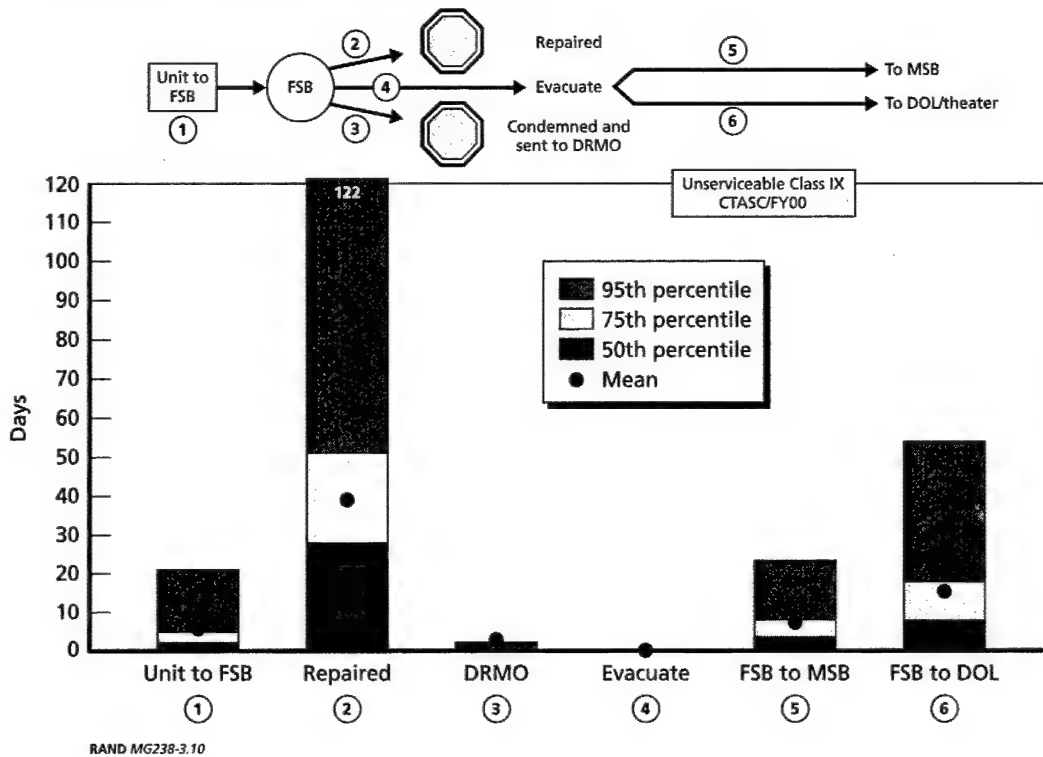
From the CTASC data, we developed a set of standard metrics¹¹ to help guide and evaluate improvement efforts. Three sets of metrics, corresponding to logistics echelons, were developed to show a generalized end-to-end flow of unserviceable items through the RL pipeline. The first set depicts FSB-level processes, the second set depicts MSB-level processes, and the third set depicts DOL/theater-level processes. Figure 3.10 shows the general format for the FSB level with Army-wide data for FY00. In this section we discuss the metric format first; Army-wide RL performance for all three levels is presented and discussed in subsequent sections.

The metrics in Figure 3.10 correspond to the definitions given in the previous table. Across the top of the graphic is the process flow, and across the bottom are performance measurements. Each column reflects the number of days it takes to complete a given process segment. Each segment has been numbered to easily link the process or activity to the corresponding measure of performance. The black portion of the column depicts how long it took the fastest 50 percent; the light gray portion

¹⁰ In particular, the last segment, from theater/installation DOL to depot/centralized repair activity, exhibits large amounts of missing data. As seen in Table 3.1 and in Figure 3.9, we allowed two different endpoint DICs that would indicate arrival at a depot or centralized repair activity, i.e., D6A or FTZ. Below, when we portray and discuss Army-wide metrics, we discuss why we chose to use only the D6A as the time stamp for that endpoint.

¹¹ Metrics should be dynamic in the sense that they are updated and changed as needed. Once processes are improved, the frequency and type of metric measurement might change; possibly the metric will become unnecessary as improvements are institutionalized. It is also likely that new metrics will need to be developed as processes change.

Figure 3.10
Standard Metric Format for FSB-Level Processing



depicts the time for the next-fastest 25 percent; and the dark gray portion depicts the next-fastest 20 percent. From another perspective, the top of the light gray portion of each bar is the time for the fastest 75 percent (i.e., the 75th percentile) and the top of the dark gray portion of each bar is the time it took to complete the fastest 95 percent (i.e., the 95th percentile).

Moving from left to right in Figure 3.10, the flow begins with the customer turn-in process with its corresponding metric labeled with the circled numeral 1. After turn-in, we consider three possible dispositions at the FSB level: the item is repaired (metric 2); the item is condemned and sent to DRMO (metric 3); or the item is evacuated (or passed on) to a higher organizational level (metric 4). Some items may be immediately evacuated to a higher level in accordance with the item's repair-level code, while others may first be sent to maintenance and then condemned as appropriate or evacuated higher if found not repairable at the FSB.

Items that are evacuated from an FSB have two possible destinations—either an MSB or the DOL (for Army units outside the continental United States, there may be a theater or regional logistics operation that corresponds to the DOL). We can measure both in-transit times from DIC time stamps in CTASC; metric 5 is for items going to an MSB and metric 6 is for items going to the DOL or theater-level

logistics operation.¹² FSB shipments to depot repair activities do not typically flow directly but rather are processed and shipped through the DOL level first.

Army-Wide RL Performance

Based on our standard metric depiction by level, we next examine actual Army performance. For our purposes here, Army performance, or an Army-wide perspective, is defined as pertaining to the active component in the following MACOMs: USAREUR, EUSA, USARPAC, FORSCOM, and TRADOC.¹³

For purposes of establishing a baseline measurement, the metrics that follow are for the reverse flow of unserviceable Class IX items during the period 1 October 1999 through 30 September 2000 (i.e., FY00). The flows that are extracted from the CTASC database are “completed” documents, i.e., those that reflect an item reaching one of three defined endpoints:

- repaired (returned from maintenance with a serviceable condition code)
- condemned (sent to DRMO with condition code H)
- evacuated to depot/SOR (receipted by supply activity at wholesale/centralized repair activity)

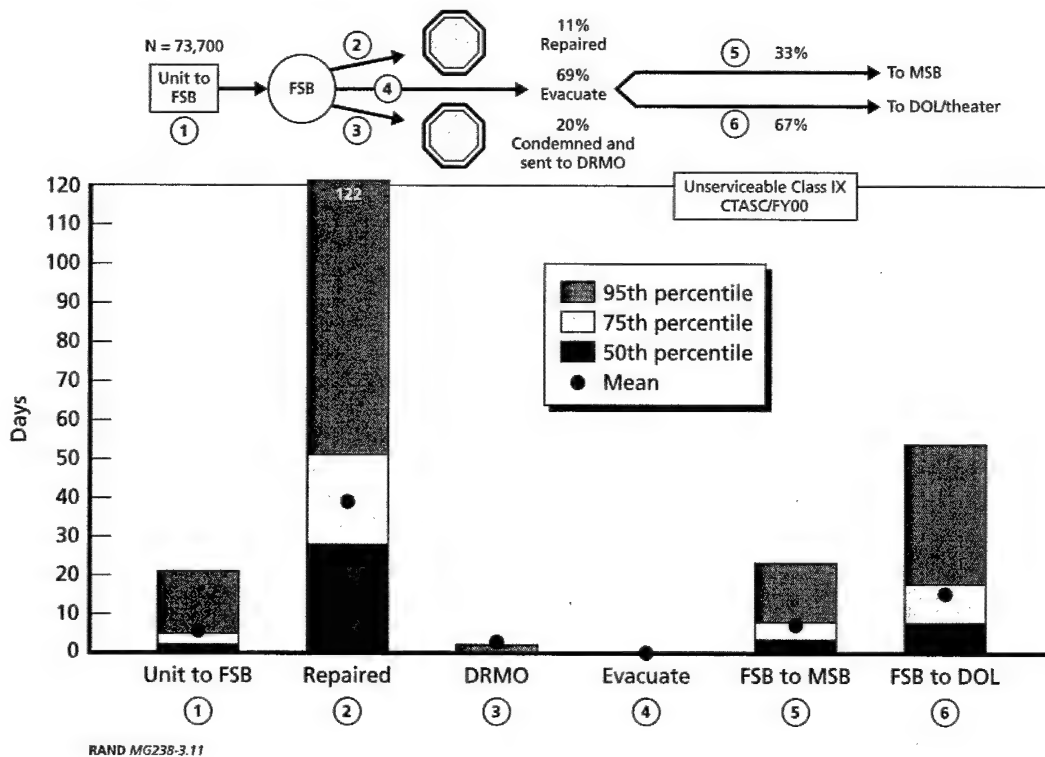
As shown in Figure 3.11, more than 73,700 unserviceable Class IX documents that were initiated by an FSB customer were completed (i.e., reached one of the defined reverse pipeline endpoints: repaired, condemned, evacuated to depot/centralized SOR) during the FY00 baseline period. The FSB turn-in process (metric 1, document date to receipt entered into SARSS at the SSA) has a mean of 5.9 days, with half of the turn-ins taking 2 days or less. However, 5 percent of the turn-ins took more than 21 days. Although relatively short, the nature of the process suggests that this is a segment that can easily be improved. The task is fairly simple and straightforward: take the part for turn-in to the unit’s SSA along with any required paperwork. The measurement of this segment is very conservative, since it begins when the mechanic/customer is ready to turn in the unserviceable item and creates the turn-in document.¹⁴

¹² As discussed earlier, if RF data were captured, the overall transit segment (metrics 5 and 6) could be further subdivided to capture more details of the movement process.

¹³ USAREUR is U.S. Army Europe, EUSA is Eighth U.S. Army (Korea), USARPAC is U.S. Army Pacific, FORSCOM is Forces Command (CONUS), and TRADOC is Training and Doctrine Command (CONUS).

¹⁴ Army procedures allow the mechanic a choice as to when the document is created—either at the time the fault is identified and a replacement part ordered, or when that replacement part is received. The first practice is more stringent and reflects a longer turn-in process. Most appear to use the latter procedure, i.e., creating the turn-in document when the replacement part is received. The different practices may account for the longest 5 percent taking more than 21 days, as noted above.

Figure 3.11
FSB Processing of Unserviceable Retrograde



Metric 2 reflects the repair process time of Army FSB maintenance shops.¹⁵ Although comparatively long, it encompasses wait time, time to troubleshoot and repair, and probably includes batching of items before return to the SSA. The end result is value recovery for the Army, since the process yields a serviceable part. These data are based on more than 6,700 successful repairs by FSBs throughout the active Army.

Metrics 3 and 4 reflect that little time is spent to condemn parts or to process unserviceable parts that are not repaired by FSB shops for evacuation to a higher echelon of repair. Seventy-five percent of the items that end up being condemned are processed the same day they are turned in; 5 percent take more than 2 days. Almost 70 percent of the items turned in to FSBs are evacuated; 95 percent of those are processed on the same day they are turned in.

Metrics 5 and 6 reflect another candidate area for process improvement: transit time to another organization. Metric 5 captures movement time to an MSB and is

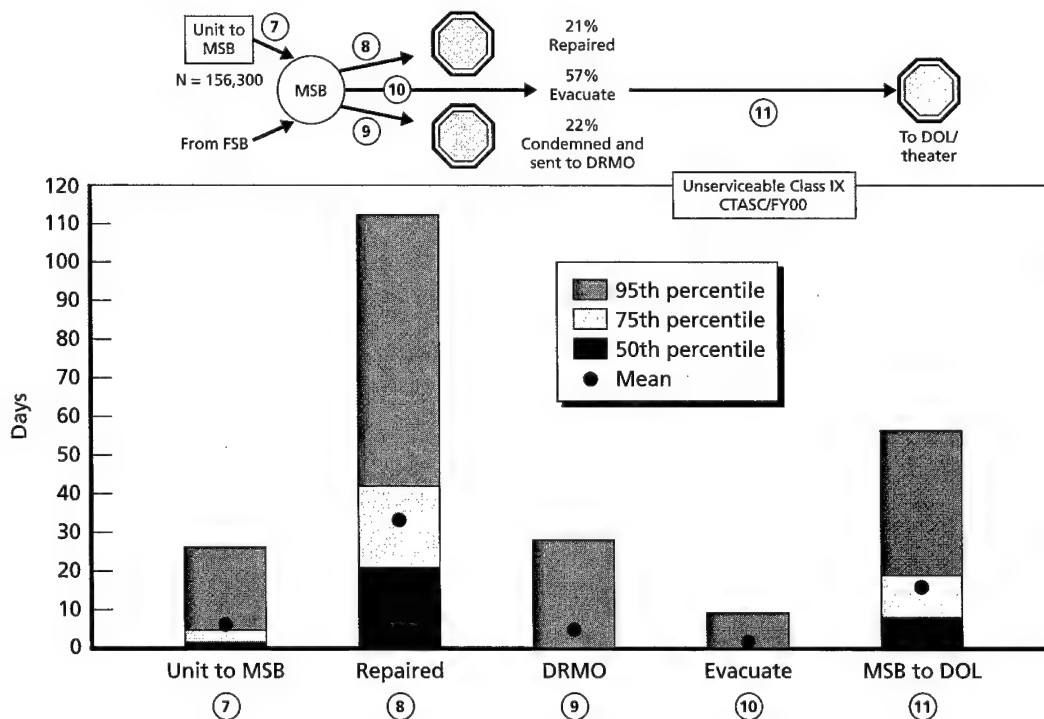
¹⁵ Repair time that does not result in a successful repair is not captured in this metric. If the mechanic ends up condemning the item, the repair time spent becomes part of metric 3. Similarly, if the mechanic cannot repair it and evacuates it to a higher level, any repair time spent becomes part of metric 4.

the shorter of the two by 8 days on average. Still, one-quarter of the items evacuated to an MSB take more than 8 days to move. As metric 6 indicates, one-quarter of the items evacuated from an FSB directly to DOL or theater repair activities take more than 18 days; even more indicative of the need for process improvement is that 5 percent take longer than 54 days to arrive. These times include awaiting pickup and actual movement.

As depicted in Figure 3.12, more than 156,000 unserviceable reparables were processed by MSB/ASB/nondivisional supply activities during the baseline period; about 140,000 were direct turn-ins by their customers, and more than 16,000 unserviceable items arrived from FSBs. Metric 7, the MSB customer turn-in process, reflects performance similar to customer turn-ins to FSBs, but with somewhat more variability, as suggested by a 95th percentile of 26 days.

Repair process time is noticeably shorter than that of FSBs and is significant in that more than 30,900 repairs are reflected in metric 8 as compared to the 6,700 repairs by FSBs (metric 2). Neither the volume nor the comparatively faster repairs should be surprising, since there is greater repair capability located in MSBs and ASBs.

Figure 3.12
MSB Processing of Unserviceable Retrograde

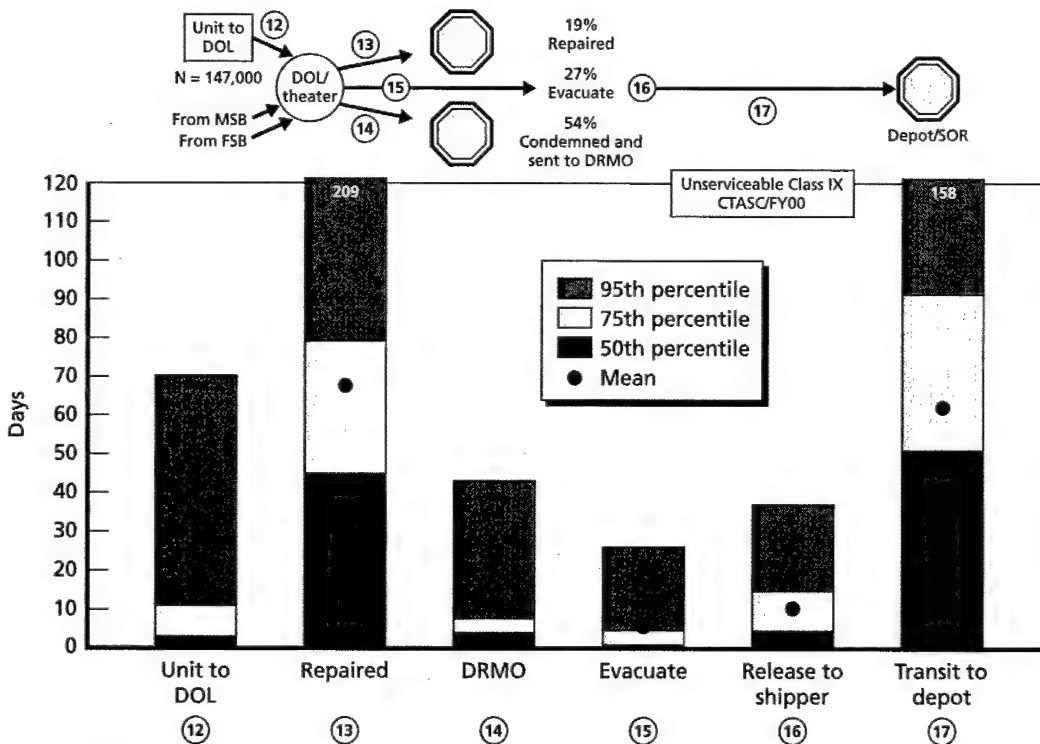


As in the FSBs, MSB DRMO and evacuation processes are short—the same day for 75 percent of the items—but both processes have more variability, as reflected by the 95th percentile of 28 and 9 days in comparison to the 95th percentile of 2 and 0 days (i.e., the same day), respectively, at the FSB level. The longer tail of the DRMO process may reflect unsuccessful attempts to repair the item before finally condemning it.

Nearly 60 percent of the items that entered an MSB were evacuated to the DOL/theater level. The transit process averaged 16 days, with 75 percent taking up to 19 days and 5 percent taking more than 56 days. The addition of RF tag data could help in analyzing subsegments of the movement process to identify potential bottlenecks caused by batching or poor synchronization.

As shown in Figure 3.13, there were over 22,000 customer turn-ins Army-wide directly to the DOL/theater level during FY00, plus 126,000 from FSB and MSB levels, for a total of about 147,000 documents. Customer turn-in processing performance (metric 12) was significantly longer than for either FSBs or MSBs, averaging 15 days, with 5 percent taking more than 70 days.

Figure 3.13
Theater/DOL Processing of Unserviceable Retrograde



Repair times were lengthy, with a mean of almost 70 days and a 95th percentile of 209 days. Some of this may be expected, as the DOLs typically have greater repair capabilities and will attempt to make difficult repairs that other levels would not even consider. Over 28,200 successful repairs were conducted during FY00 at DOL/theater-level repair activities.

DOL/theater-level DRMO processing and evacuation times are longer than other echelons. More than half of the items turned in to the DOL/theater were condemned; most were disposed of within 8 days, but 5 percent took longer than 43 days.

Twenty-seven percent of unserviceable reparable flowing through DOLs/theater levels were evacuated to depot/centralized repair activities. Metric 15 includes the time from receipt in the DOL/theater activity until identification that the item needs to be evacuated to a higher echelon of repair, i.e., depot/centralized repair activity. For metric 15, items averaged 6.3 days and 5 percent took longer than 26 days. Metric 16 reflects the performance times for processing/preparing these items for shipment to depot or other centralized repair activities. The process begins from the point that an item is identified for evacuation until it is released to a shipper for transportation; activities include preparation for shipment, such as cleaning, packaging, and crating, as well as wait time for pickup by a shipper. Half the items took up to 5 days, with a mean of almost 11 days.

Once picked up, the time to move items to a depot/SOR averaged over 62 days across the Army, with 5 percent taking longer than 158 days. The long times for this process segment are affected by long(er) distances and the increased complexity of overseas shipments (i.e., increased nodes and modes). However, there may also be processing or receiving issues at the wholesale repair points (depot/SOR); RF tag data would help pinpoint where to focus improvement efforts.

MACOM Performance on Key Segments

To further analyze Army RL performance, we next examine individual MACOM metrics. The MACOMs included in this report are USAREUR, EUSA in Korea, USARPAC, FORSCOM, and TRADOC. Each MACOM was defined by mapping unit-specific RICs¹⁶ by level, i.e., FSB, MSB, or DOL/theater, and RL data were extracted accordingly.

To gain a broad perspective for initial analysis of the RL flows by MACOM, we examine the disposition of unserviceable reparable in terms of the three defined

¹⁶ A unique Routing Identifier Code or RIC is assigned to individual SSAs/supply sources at specific geographical locations. For example, "WBR" is the RIC used to identify the SSA in the 565th Repair Parts Company at Fort Hood, Texas.

endpoints, i.e., how much in terms of volume and value is (1) repaired, (2) condemned and sent to DRMO, or (3) evacuated to AMC depot repair activities. This provides an initial perspective on how much activity occurred by endpoint and organization.

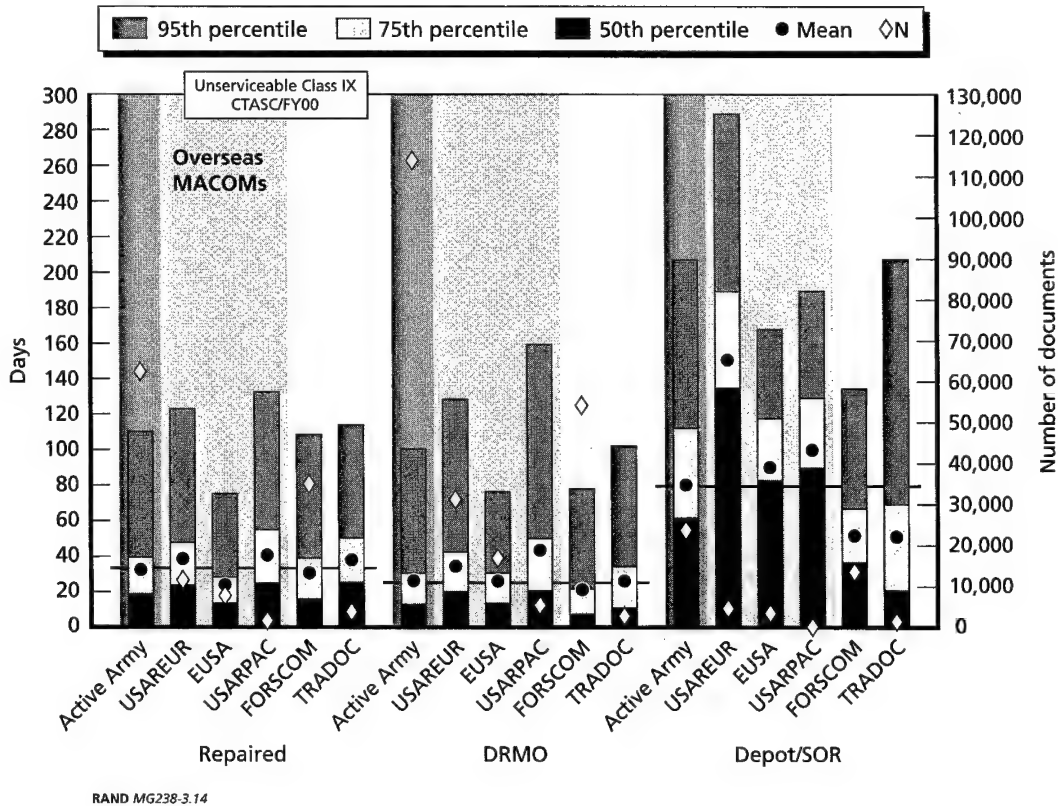
Next we examine metrics for key segments in the RL process, such as customer turn-ins, on-post transit, the transit from post to centralized stocks, and repair. These can be tracked and analyzed for possible improvements. The turn-in process begins the RL process and has been identified by many as unduly time-consuming, with many delays. It has also been observed that the transit of retrograde materiel (including wait time) from one organization to another (even on the same installation) tends to consume large amounts of time—making those segments candidates for improvement.

The size or volume of the reverse pipeline should also have a reduction goal, as it represents investment in inventory. We measure how many unserviceables are in the system—in particular, items that appear to have stopped moving toward one of the three endpoints. The volume and value of these items reflect investment that is unproductive in its current location and/or condition. Reduction from an Army-wide perspective can lead to less investment in stocks overall as well as increased equipment readiness.

Figure 3.14 depicts a by-MACOM comparison of the time it took for an unserviceable reparable to reach one of the three defined endpoints. As is apparent, the MACOMs differ considerably. It is important to remember that there is not a “level playing field” when comparing MACOMs; however, we may gain some insights by doing so. Differences in MACOM characteristics include geographic dispersion of units (customers, maintenance shops, and SSAs) and location (OCONUS versus CONUS), missions, and assigned equipment, as well as mere size. For example, the metrics here are based on different volumes of activity; generally the RL data reflect that FORSCOM units account for about 55 percent of the volume, followed by USAREUR (22 percent), EUSA (14 percent), TRADOC (5 percent), and USARPAC (4 percent).

Generally, across the three endpoints, we note in Figure 3.14 that the overseas MACOMs (USAREUR, EUSA, and USARPAC) take longer to move items through the RL pipeline and FORSCOM tends to move items more quickly. In other words, the means for overseas MACOMs tend to be higher than the overall Army mean, while the FORSCOM means tend to be lower (faster). Variability, as reflected by the 95th percentile, also tends to be higher overseas. OCONUS operations typically face more complex procedures as the Army interacts with foreign national providers (e.g., workers, transporters, etc.) and has to deal with greater geographical constraints; in other words, logistics processing and movement of retrograde materiel typically take somewhat longer than CONUS operations.

Figure 3.14
Total Time to Reach Endpoints by MACOM



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Repaired Endpoint

The overall Army mean for unserviceables that are repaired at echelons below the depot or centralized source of repair (SOR) level was just over 33 days. That is the time from the document date used to turn in the item until the item returns from a maintenance shop with a serviceable condition code. The 50th percentile for the Army was 20 days, with MACOMs ranging from 15 to 26 days; MACOM means varied between 25 and 42 days. In particular, we also note that USAREUR and USARPAC tend to experience greater variability.

DRMO (Condemned) Endpoint

The Army mean time from when unserviceables are turned in until they are condemned and sent to DRMO is about 28 days. 50th percentiles range from 9 to 22 days, and there is notable variability in USARPAC, as reflected by the 95th percentile. One observation is that these items are the least valuable in terms of value recovery.

ery but are quickest in reaching an endpoint. From another perspective, this is good because they leave the system and reduce clutter.

Evacuated to AMC Depot Endpoint

The Army mean for unserviceable items whose endpoint becomes an AMC depot is almost 82 days, and this does not include any depot repair time. With longer transit distances and higher process complexity, the longer times for OCONUS are not unexpected; however, USAREUR's performance is notably longer—even at the 50th percentile. As expected, FORSCOM has much shorter times due to CONUS locations. Even so, with the magnitudes of the times reflected, it is likely that there are improvement opportunities in this area.

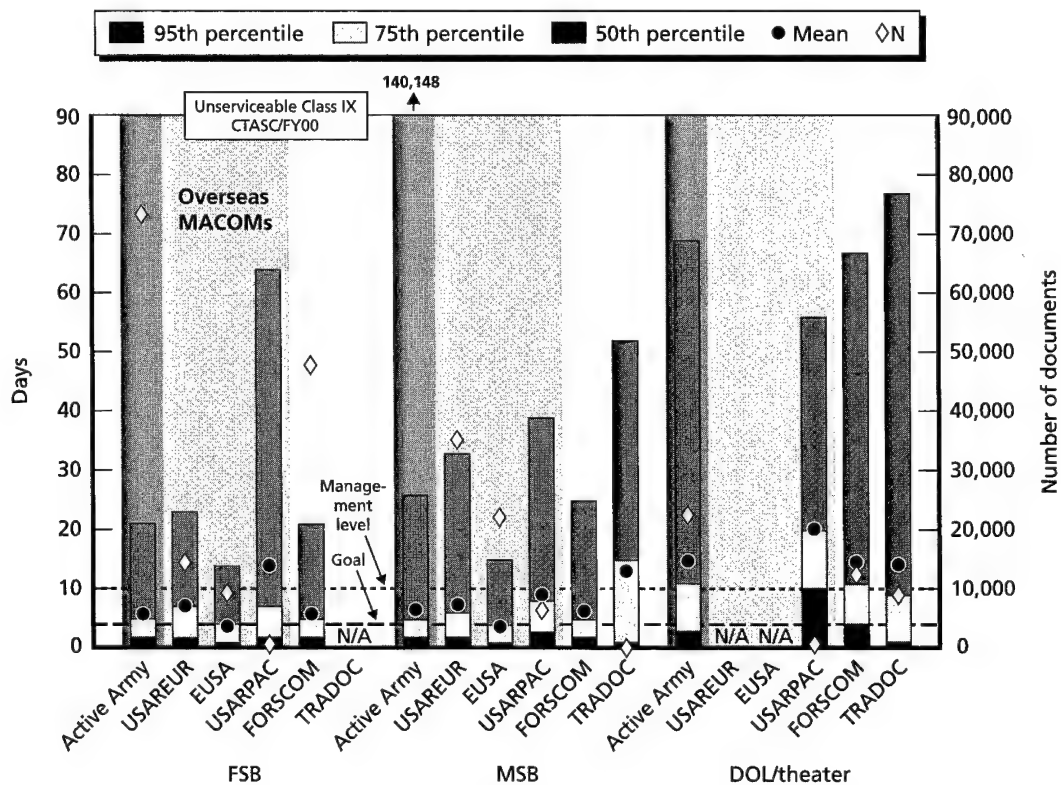
Customer Turn-In Segment

Next we examine the beginning point for RL: customer turn-in time. A mechanic usually turns in an unserviceable part, component, or carcass to the maintenance shop office and the unit parts clerk turns it in to the supporting SSA along with any required documents; this metric measures the elapsed time between the using organization (i.e., the maintenance shop) and entry into the supply system (i.e., receipt at an SSA). The clock starts when maintenance creates a turn-in document. Figure 3.15 shows that there is much variability in performance. The median performance for most commands tends to be around 2 days, but the means are higher because of the large variability. For this metric, Army Regulation 710-2 sets a goal of 5 days and requires management-level review at 10 days, shown by the dotted lines on the figure. While many organizations seem to be within those standards, one should question whether these levels are appropriate—this measures a fairly simple turn-in process, which begins the whole value recovery effort. As noted earlier, one can make a sound argument that the “clock” should begin even earlier, i.e., when the part is identified as broken and a replacement part is ordered (or at least from the time the replacement part is received).

On-Post/In-Theater Transit Segments

Local transit time metrics (Figure 3.16) capture the movement from one level or echelon to another, starting with “release” for shipment until receipt at the next echelon; this includes waiting and transit time. For CONUS MACOMs these movements are relatively short—sometimes merely across a parking lot or down the street. However, “local” becomes relative for OCONUS posts, where the movement is typically much longer (for example, in USAREUR, from the Frankfurt area to Kaiserslautern is around 70 miles). In EUSA, the road conditions and traffic congestion can also cause delays in moving unserviceables in the area around Seoul, Korea and particularly from the 2nd Infantry Division Forward area north of Seoul to

Figure 3.15
Value Recovery Process Begins with Customer Turn-In Segment



SOURCE: AR710-2, Table 1-1.

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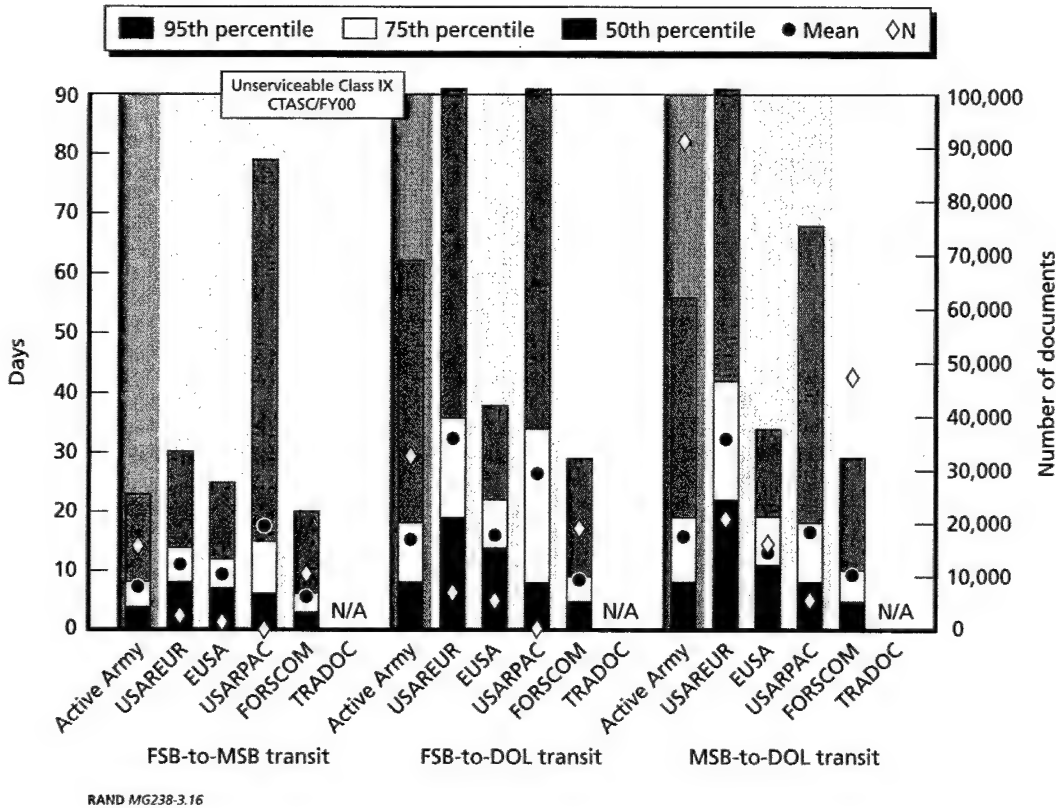
Camp Carroll. The metrics for all MACOMs suggest that these transit times should be investigated for possible improvements. RF tag data could help identify more specifically where time delays occur.

Transit to Off-Post Centralized Repair Segment

Figure 3.17 depicts the elapsed time from when an item is turned over to a shipper until it is receipted at a repair depot or centralized SOR (more specifically, the DLA supply activity at that location). The overall Army mean is over 63 days for an unserviceable to be delivered from a post or theater to a depot or centralized SOR. However, the Army mean combines the shorter times for FORSCOM in CONUS with the longer transit times for OCONUS MACOMs—predominantly by sealift over great distances.

When we compare forward OCONUS transit times for sealift shipments for each theater with the RL performance for that theater, it is apparent that these times

Figure 3.16
Local Transit times Indicate Significant Delays



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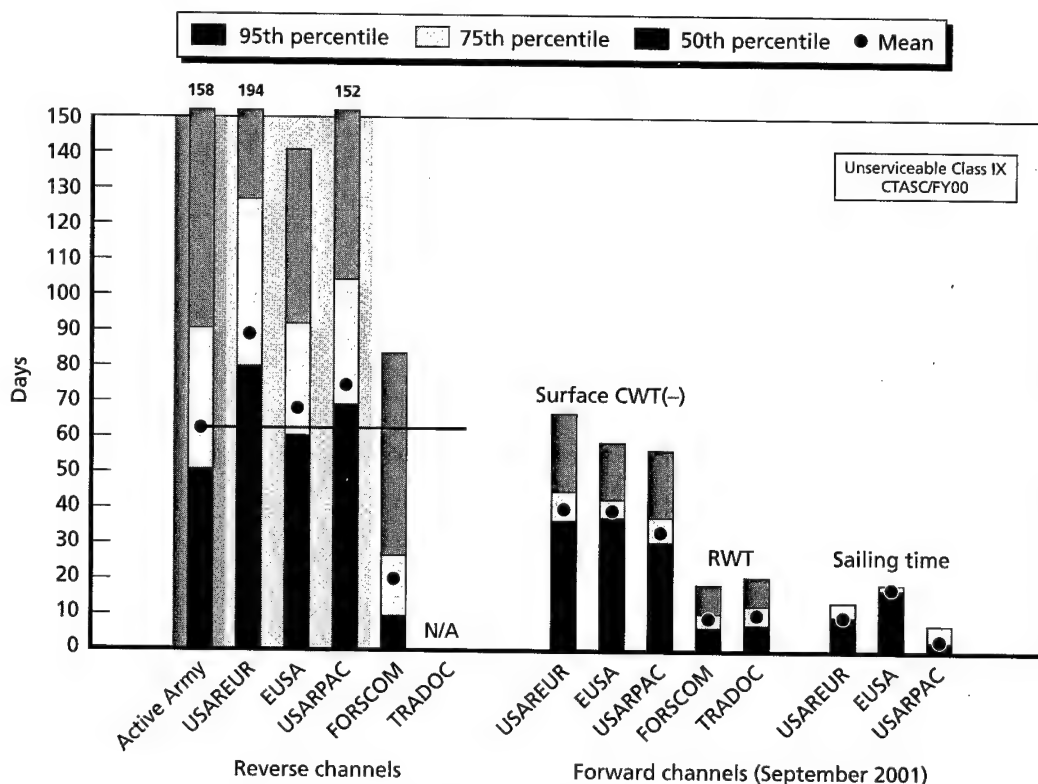
can be significantly shortened. The sailing time performance provides a reasonable estimation of the minimum performance that might be achieved for this RL segment.

Volume and Value of Reverse Pipeline for Unserviceable Repairables

Using the Asset Balance File (ABF) in the CTASC database, we can capture the quantity of unserviceable stock on-hand that is not in a supply activity at an AMC depot, as shown in Figure 3.18.¹⁷ These data were captured once a month (generally at the end of the month) and plotted to depict the trend over time. The data for 2002 reflect that FORSCOM has the most unserviceable repairables at local levels,

¹⁷ The increase in the amount of unserviceables shown in Figure 3.18 is most likely due to the start of the Army's transition to Single Stock Fund (SSF) in FY01. Prior to the transition, there were two separate stock funds owned by different organizations; these have been gradually merged, creating a number of credit and pricing issues. Under SSF, AMC also assumes ownership of unserviceable repairables much earlier in the returns process; an observed change is that unserviceables do not automatically move to depot storage awaiting induction to a repair line as they did before SSF. See Pint et al. (2002) for further discussion of SSF and related issues.

Figure 3.17
Transit Time from Post/Theater to Depot Repair Activity



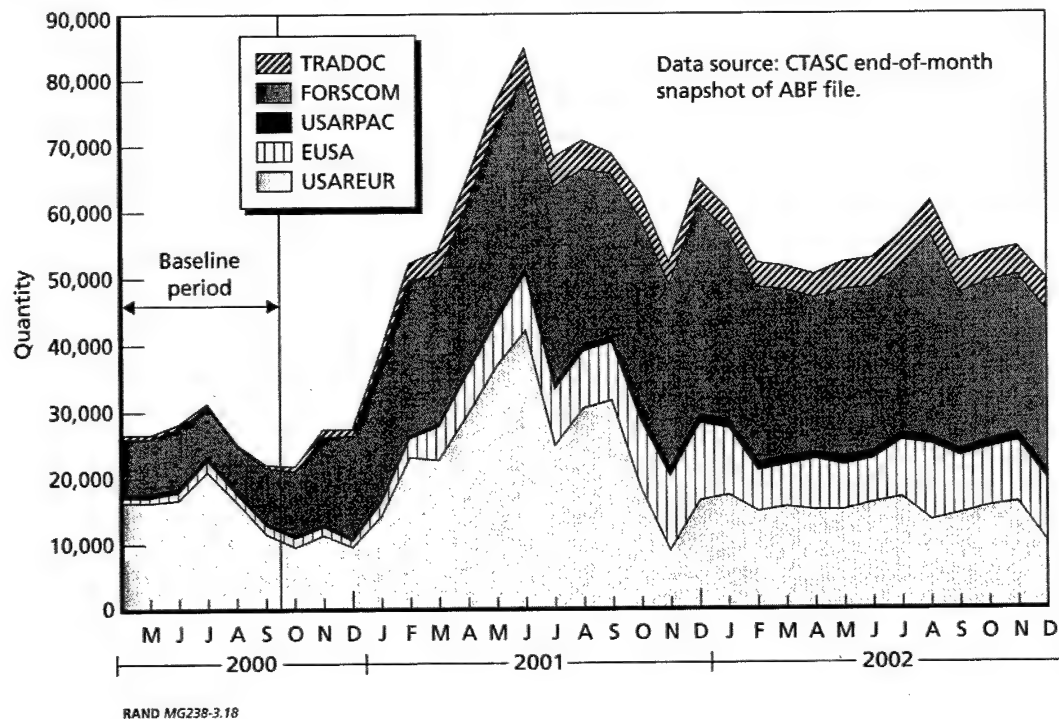
SOURCE: RAND integrated strategic distribution database.

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followed by USAREUR. Comparing December 2002 with the end of the baseline period, September 2000, Figure 3.18 shows that most MACOMs have increased quantities of unserviceables in process. These stocks are components and parts that have been identified as repairable items that the Army intends to repair and return to stock if possible; as a metric this should be tracked over time as a measure of the size of the RL pipeline that is in work (or in process). The impact of improvement efforts that are intended to reduce the amount of unserviceable items in process should be reflected in this metric. Increases or high quantities of unserviceables in the RL pipeline may indicate unproductive investment in inventory.

In Figure 3.19, the total AMDF value of unserviceable on-hand stock throughout the Army is overlaid on the quantities shown in Figure 3.18. The value of these inventories tends to change in the direction that quantity changes; for example, if quantity increases, there is a corresponding change in value. However, there are some unexplained anomalies beginning in January 2002, where the quantity decreases but

Figure 3.18
Quantity of Unserviceable Items in Process



the value increases; these relative changes will be driven by the particular mix of low- and high-dollar items in the RL pipeline. Trends over a longer period of time may indicate more specific conditions, and changes may be linked to particular events or actions.

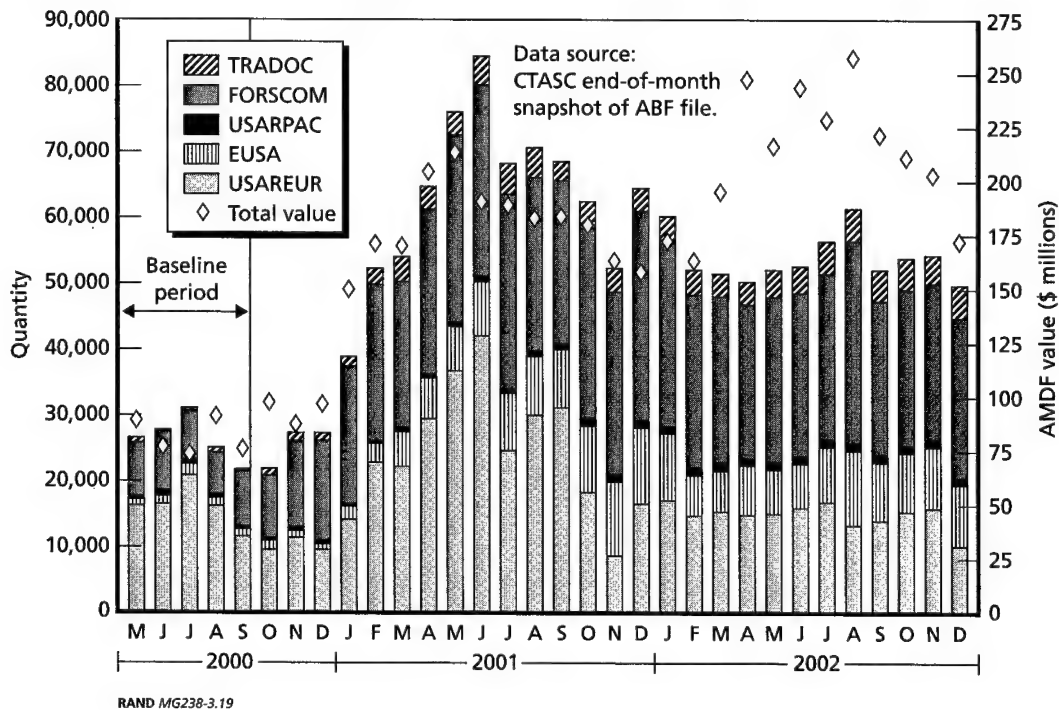
The collection of RL data makes it possible to examine the same set of metrics for installations and individual units and organizations within MACOMs and installations. Analysis at these lower levels could be used to identify and track the success of specific improvements.

Summary of Recommended Measurements

The metrics developed and described above will be useful in focusing improvement efforts. The metrics can be categorized in two groups: overall performance metrics and segment process metrics.

Overall metrics summarize the general condition or state of the reverse logistics/retrograde system. These metrics could be stratified along management responsibility lines, for example, stratifying by parts in the National Maintenance Program. Four metrics are recommended:

Figure 3.19
On-Hand Quantity and Value of Unserviceable Items



- Total Time to Repair
- Total Time to DRMO (condemnation)
- Total Time to Receipt at Centralized Repair Site
- Total Quantity and Value in the Retrograde Pipeline

Process metrics focus on several of the key processes performed in handling unserviceable reparable in the reverse logistics pipeline:

- Customer Turn-In Process
- On-Post Transit Process
- Transit Off-Post to Centralized Repair Site

While the processes remain the same and the metrics are applicable, the mechanisms to calculate the data in this research have changed since the implementation of SSF. To bring the metrics up to current time periods would require exploration of different databases and development of new programming tools.

Improving the Reverse Logistics Process

The next steps in the Define-Measure-Improve (D-M-I) methodology are to identify improvement opportunities, implement those improvements, measure the resulting performance, evaluate their success, and look for additional improvement opportunities. “Improvement” has several interrelated dimensions to consider, such as increased velocity, reduced variability, and a higher rate of value recovery. Ultimately the goal is more responsive sustainment and support of Army soldiers at reduced inventory costs. Reduced variability adds another advantage: reducing the workload burden imposed by the reverse pipeline.

In this chapter, we present some preliminary observations and then suggest areas where improvement opportunities are likely to yield systemwide benefits. First efforts should focus on the process segments where the metrics indicate long delays, as well as on critical segments.¹ Such efforts will improve speed and reduce variability.

Streamline Installation Turn-In Procedures

The following recommendations are offered with the objective of eliminating non-value-adding tasks for the soldier and to reduce overall materiel and transportation costs for the Army.

- Turn-in requirements appear to cause delays. They should be examined with an eye toward streamlining and a goal of minimizing the requirements on the

¹ Dowlatshahi (“Developing a Theory of Reverse Logistics,” *Interfaces*, May–June 2000) offers seven operational factors—customer, cost-benefit analysis, transportation, warehousing, supply management, remanufacturing/recycling, and packaging—for a reverse logistics system. In this report, we have restricted our view of the Army’s RL system to primary flows within an existing system—as compared to redesigning that system. Dowlatshahi’s perspective would be useful to examine redefinition/redesign of the Army system to include broader concepts of what should be remanufactured, the design of components and equipment specifically with remanufacturing in mind, etc.

maintenance activity initiating the turn-in process. The resulting requirements should be coordinated at all levels.²

- To reduce the turn-in time, the Army should consider establishing a "Due-In from Maintenance" requirement for turning in an unserviceable repairable "carcass" when the serviceable replacement component is ordered and issued. This requirement should include time requirements and reports that focus management attention on delays.
- Another way to reduce turn-in time is to review and determine the minimum essential documentation needed to process the items being turned in. If a document is not used or duplicates another, it should be eliminated. Again, this review should seek to minimize the burden on organizations initiating a turn-in.
- A review of essential cleaning, draining, safety, and protective measures could also lead to streamlining and simplifying the turn-in process, thereby reducing the workload burden on the field. There are reasonable standards that should be determined and consistently applied to balance costs and benefits.
- Consider differences in packaging requirements for intra-post transport versus those for items that enter commercial or military transportation systems for off-post delivery. Identify the appropriate requirements by level and then place needed packaging material and/or equipment there. For example, an unserviceable transfer case at the DS or organizational level should be drained (but not steam-cleaned) and caps should be installed as appropriate. It could be transported via pallet to the DOL or local repair point. If necessary for off-post shipment, additional or alternative packaging as applicable for transportation over-the-road or air shipment would be applied there.
- When issued parts are received at the point of equipment repair, the packing material should be retained and used to package the unserviceable part for turn-in. This would eliminate many of the packaging issues.
- Similarly, the Army (or DoD) could consider including the paperwork necessary for the turn-in of unserviceable repairables with the serviceable issue. As an example, when customers receive a laser printer toner cartridge from Hewlett-Packard, they also receive a reusable package with all the necessary UPS labels to send the used cartridge back.³

² In his review of this report, Dr. Dale Rogers offered the following perspectives of commercial turn-in experiences. He notes that in the private sector, the front-line gatekeeping personnel at the retail service desk are notoriously uninterested in documenting much about the returned item unless the service desk system requires them to do so. The turn-in process has to be simplified to make it happen. Farther into the RL process (such as at a central return center), more detailed data may be developed. It usually increases the velocity of the reverse logistics system to evacuate first with simple documentation, with a detailed analysis of the problem occurring later in the flow. Making it easy for frontline personnel will likely speed up the process.

³ Ron Giuntini and Tom Andel, "Master the Six R's of Reverse Logistics," *Integrated Warehousing & Distribution*, March 1995.

Route and Hold Items with "Next Step" in Mind

Set Routing Identifier Code (RIC) Ship-To table parameters so that items flow as directly as possible; for example, components repaired at the DOL should flow directly from the FSB. Under SSF there may be requirements to direct documentation to intermediate organizations, i.e., an Army Working Capital Fund (AWCF) supply organization on post, even if the item may be routed more directly.

Expeditious return of all unserviceable reparables to appropriate designated location(s) for eventual repair has potential advantages. Foremost is visibility of system-wide carcasses to the item manager as well as reduced collection and shipping cost and time when a repair decision is made. This should occur whether or not there is a current active repair program for the item.

A number of broader, systemwide issues need to be worked out concerning the above recommendations. In particular, transfer fees that are in place for DLA issues and receipts from DLA warehouses should be examined and adjusted so that the immediate economic decision matches a longer-range perspective. Also, second-destination transportation charges should be re-evaluated.

Integrate Reverse Pipeline with Forward Pipeline

Integration of the Army's forward and reverse pipelines potentially offers better performance and perhaps cost savings. The economics of volume can be realized by integrating some of the reverse and forward flows as well as through using the core competencies of different organizations like DLA distribution centers.

Studies should be conducted to examine opportunities for integration and to implement cost-effective, time-definite/scheduled reverse distribution channels. Such channels could consist of hub-and-spoke networks or "milk runs." Further, for OCONUS MACOMs, one might even eliminate in-theater sorting by destination, thus creating higher volumes in return channels to SDPs.

DLA's core competency in sorting and distribution should be fully explored. Parts repaired at depot or centralized SOR facilities (which represent successful value recovery) could be positioned at SDPs for more immediate movement to customers when a demand is received. Holding these repaired items at the repair site, as is often the current practice, increases CWT. Careful consideration based on historical demands should give an accurate idea of how much of each item to stock at each SDP.

The analyses described here to evaluate reverse distribution networks might be combined with the aforementioned need to streamline the flow so items are routed to repair facilities as directly as possible. The next step might be to expand this broader network analysis to determine opportunities for distribution and repair facility nationalization.

Examine Potential Applicability of Commercial Software Solutions

A recent article on returns management⁴ cites two case studies where software solutions helped automate the return process and thus reduced expenses and potential errors. In both cases, the RL process innovations were developed in partnership with FedEx and included an online processing system. Examples of improvement applications included online return templates, return label printout capability, scannable bar codes, end-to-end electronic returns processing, and inventory visibility. One company reduced the man-hours required to process a returns pickup by about 70 percent; this involved an Internet-based returns management system that streamlined coordination between the customer initiating a return, FedEx as the transportation agent, and the company. The Army could potentially achieve similar savings by considering regularly scheduled shipping of unserviceables along with serviceables as discussed above rather than arranging less-than-truckload pickups one by one as needed. The automated and streamlined procedures also provide savings by eliminating unnecessary intermediate handling points in the returns process.

An important point emphasized is that “a haphazard returns process can result in returns’ not receiving a correct disposition. For example, there is a chance that an item that could be sold as new will be sent to a salvage or discount company for disposal, resulting in lost revenue.”⁵ Equivalently for the Army, this means the possible loss of serviceable assets—potentially degrading readiness and increasing inventory investment. Better automation and information processing aids should improve the quality and timeliness of data. Improving both of these data attributes should enable more effective reverse pipeline process monitoring and control. Additionally, this may facilitate the development of process redesign ideas by easing analysis.

Financial Incentives Should Be Consistent with Improvement Efforts

Financial incentives such as credit policies, transportation fee structures, surcharges, etc. must necessarily align with and support decisions to improve the flow of unserviceable reparables to an endpoint. Such issues are inherent in influencing the behavior of the various members of the reverse supply chain. While not investigated di-

⁴ Christopher D. Norek, “Returns Management: Making Order Out of Chaos,” *Supply Chain Management Review*, May/June 2002, p. 36. In place of the term reverse logistics, Norek defines a new term, *enterprise returns management* (ERM). He defines ERM as “the management of the return across the enterprise of the company, including return approval, transportation coordination, tracking of a return, receipt and disposition of the return, and crediting the customer account. This view includes all the information related to the return as it progresses from the customer back to the supplier’s system.”

⁵ *Ibid.*, pp. 37–38.

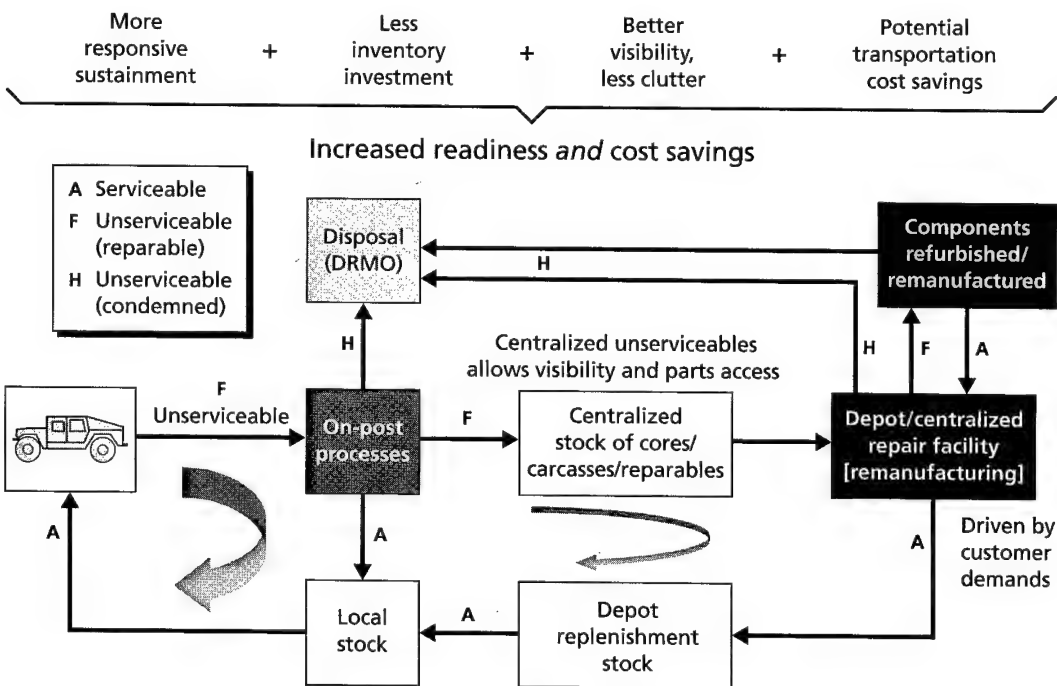
rectly in this work, these issues are important; for detailed examination and discussion of financial incentives, see Pint et al. (2002).

Conclusion

Responsive repair capability plus timely throughput are two keys to improved RL flows. A broad range of activities needs to be examined, understood, and improved, beginning with timely turn-in of unserviceable Class IX reparable, to redistribution of serviceable retrograde, to physical movement of retrograde, to in-transit visibility, and ultimately including the places of value recovery—repair shops and depots.

The benefits of improved reverse logistics flows are summarized in Figure 4.1. This analysis deliberately truncated its view of the reverse logistics pipeline by omitting the repair/refurbishment/remanufacturing activities of depot or depot-like centralized repair locations as depicted in Figure 4.1. These “repair” activities are integral

Figure 4.1
Improved RL Pipeline Has Important Cost and Readiness Implications



Appropriate financial incentives are necessary conditions: credit policy, transportation fee structures, surcharges, etc.

parts that must be carefully and deliberately linked (even synchronized to the extent possible) to the “flow” portions of the RL pipeline. A pull system approach⁶ to depot/centralized repair can lead to significant savings in inventory investment as well as improved fill rates.⁷ A significant benefit of a pull system is the coordination and linkage of the parts so that parts flow without delay.

The Army also needs to integrate systems between levels—between forward and reverse processes and between organizations. Ultimately the Army needs to support and focus on the soldier with the equipment—RL may be what he/she depends on for valuable and scarce replacement parts in a fast-moving operation.

⁶ A pull system is a cascading system of instructions where actions/activities are triggered by a customer demand. The intent is to minimize inventories while meeting expected response time criteria. For more on this and related concepts, see Womack and Jones (1996).

⁷ Blumberg (2000).

The Army's Four-Level Maintenance System

Organizational maintenance focuses on end item readiness and conducts preventive maintenance, scheduled services, and end item repair (primarily replacement of components on end items).

Direct support (DS) units provide mobile, dedicated support to organizational maintenance activities, primarily focused on end item repair with limited component repair capabilities. They perform limited repair and return of components to units or repair components and put them into stock at their associated SSA.

General support (GS) is the first level of maintenance that conducts extensive component repair for stock and also handles complex end item repairs and modifications.

Depots are industrial-type activities that are the primary suppliers of serviceable repairable spare parts, and they perform overhaul and modification of end items.

Organizational and DS maintenance do what is necessary to keep end items operational during battle, GS maintenance provides DS backup and supports the theater supply system, and depot maintenance serves as the industrial base for repairable items and the linkage to the commercial sector.

Within a division (Army of Excellence design), DS maintenance is provided to maneuver brigades by FSBs. They generally have fire control, armament, automotive, small arms, communication equipment, and night-vision repair capabilities for components and repairs that do not require sophisticated TMDE and technical skills. In addition, the MSB provides backup to the FSBs. MSBs also provide direct support to divisional units (e.g., the Signal Battalion), and they have broader technical capabilities than FSBs (adding missile and battery shop capabilities as well as sometimes more sophisticated capabilities on the other types of repairs).

Aviation DS within a division is provided by a dedicated support battalion—usually called an ASB, without MSB backup. Nondivisional units receive DS support from separate maintenance units that are part of Corps Support Groups. When units send unserviceable materiel back through the supply chain, it passes through their DS unit (in some maneuver brigades it passes through the FSB and the MSB) and then to the appropriate GS organization. At CONUS installations this is

provided by a fixed, nondeployable activity called a DOL, while overseas organizations sometimes have active GS units. CONUS organizations generally have designated GS units in reserve components.

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